UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
James K. Carr, *Under Secretary*
Frank P. Briggs, *Assistant Secretary for Fish and Wildlife*
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, *Commissioner*
BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, *Director*

THE FISHERY FOR SCUP WITH SPECIAL REFERENCE TO FLUCTUATIONS IN YIELD AND THEIR CAUSES

by

William C. Neville and Gerald B. Talbot

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 459

Washington, D.C.

FOREWORD

In 1927, the U.S. Bureau of Fisheries began a study of the marine fishes along the Middle Atlantic States. One of the most important of these was the scup *(Stenotomus chrysops).* Emphasis was placed on this species, but data on others, including weakfish, summer flounder, butterfish, croaker, and sea bass, were collected when practicable. Considerable data were accumulated on scup by 1935, but publication funds were not then available. Later, with the beginning of World War II, fishery research in the Middle Atlantic was suspended and the data were stored.

In 1949, headquarters for the Middle Atlantic Fisheries Investigations of the Bureau was established at Beaufort, N.C., with funds allotted for a study of the Atlantic shad. The files from the old Middle Atlantic Investigation were then sent to Beaufort for storage. From time to time, since the 1930's, Federal and State biologists of the Middle Atlantic area urged that this material be published to aid their studies. The scup information was particularly valuable, for this species is being studied intensively at the present time by several agencies.

All the early material on scup was assembled. This included considerable basic data, tables and figures, and part of a rough manuscript by the senior author of this paper. He was no longer available to complete the manuscript, having accepted employment in a private organization overseas. With his consent the junior author completed the manuscript.

In undertaking this task, the junior author has attempted to use all the available data and as much of the old manuscript as possible. Considerable revision was necessary; apparently some material was missing, and data were not available to support all the conclusions reached in the original manuscript. While leaving many questions unanswered, the manuscript, as now presented, furnishes much basic data on the early fishery which should prove valuable to later workers. The conclusions in the manuscript appear sound.

The catch of scup in recent years has increased considerably, and in 1960 (the latest figures available), the catch of this species in the Middle Atlantic area, where the bulk of the catch is now landed, ranked second in poundage and fifth in value. Graphs of catches in the New England, Middle Atlantic, and Chesapeake Bay States from 1930 through 1960 are given in the appendix for reference purposes. No attempt has been made to account for the increase in catches or to relate recent catches to the conclusions in the present paper. This presumably will be attempted by those who are now studying this fishery.

During the revision of the manuscript, valuable help and suggestions were received from James R. Westman, Rutgers University; Paul E. Hamer, New Jersey Department of Fish and Game; Edward C. Raney, Cornell University; and Robert L. Edwards, Bureau of Commercial Fisheries.

Editor's note: The basic portions of this report were written in the late 1930's. Use of the present tense refers to that time. References to the U.S. Bureau of Fisheries are correct since the Fish and Wildlife Service was not established until 1940.

CONTENTS

	Page
Foreword	ii
Introduction	1
Range	3
Description of the fisheries	4
Pound nets	4
Floating traps	6
Purse seines	7
Otter trawls	8
Handlines	11
Fluctuations in yield and their causes	11
Summer fishery	12
Statistics of the fishery, New Jersey	12
Changes in total yield	12
Measurement of fluctuations	12
Causes of changes in yield	13
Transition from pound nets to offshore vessels	20
Statistics of the fishery, New York and southern New England	24
Changes in total yield	24
Measurement of fluctuations	27
Causes of changes in yield	27
Summary of summer fishery	31
Winter trawl fishery	31
Statistics of the fishery	31
Changes in total yield	31
Measurement of fluctuations	32
Causes of changes in yield	33
Hydrography	37
Summary of winter fishery	46
Tagging studies	47
Discussion	56
Summary	58
Acknowledgments	59
Literature cited	59
Appendix	61

THE FISHERY FOR SCUP WITH SPECIAL REFERENCE TO FLUCTUATIONS IN YIELD AND THEIR CAUSES

by

William C. Neville and Gerald B. Talbot

ABSTRACT

The catch of scup over the past 50 years has fluctuated widely. Data on this fishery for recent years (1922-35), obtained from State and Federal agencies, commercial fishery, and fishermen, have been analysed to determine causes of fluctuations. It was found that fluctuations in the summer fishery from New Jersey to Massachusetts were caused mainly by differences in the size of the successive year classes entering the fishery. Fluctuations in the catch of the winter trawl fishery off the Virginia Capes resulted from changes in the amount of cooling of the bottom water where these fish are found in winter. During cold-water conditions, the fish became more concentrated and were more easily caught; whereas, when the water was warmer, the fish scattered more widely and were not as readily available. Although fluctuations in catch of the summer and winter fishery have different causes, results of tagging and observations of size composition have disclosed that both fisheries draw on the same general stock.

INTRODUCTION

The shorefishes of the coastal waters of the Middle Atlantic and southern New England States undoubtedly facilitated the early colonization of this region and subsequently have supported a fishing industry of major commercial and recreational importance. Among these fishes, the scup, *Stenotomus chrysops*[1], has always been important, especially along the southern New England coast. Among the inshore species, it has usually ranked first both in quantity and in value since 1880, when the earliest catch statistics were collected. Along the coasts of New Jersey and New York, scup was relatively less important in the early years of the fishery, but of late (1929-33) tremendously increased catches have placed it third in quantity and sixth in value among the food fishes of those States.

The fluctuations in yield which have characterized the history of the species from Colonial days to the present have been at times the subject of lively discussion as to their causes (Baird, 1873; Bigelow and Welsh, 1925). Lyman (1872) stated:

> Scup were abundant when the whites first visited the country, certainly in 1621 to 1642. At some time after this, not yet ascertained, they *disappeared* wholly, and, toward the end of the last century were not known in our waters. About 1794 they reappeared, and became abundant. In 1864 they decreased very much and are at the present scarce. ******* And now, in the midst of this theorizing and seeking for evidence, rises a phenomenon which puzzles both parties of the dispute. About the first of June of this year (1871) those trappers at Saugkonnet Point who had kept their netting down until that time, were astounded to find their traps clogged with myriads of "dollar-scup," little fish about the size of a Spanish dollar. They were tipped out of the bowls by hundreds of barrelsful.

Note.--William C. Neville is now with the Columbia River Packers, Tokyo, Japan, and Gerald B. Talbot with the Tiburon Marine Laboratory, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Tiburon, Calif.

[1] Listed as *S. versicolor* by some authors.

Fluctuations in the past have been attributed to:

1. Excessive catches or wasteful fishing by new types of gear. This opinion was usually advanced by operators of old types of gear in support of their opposition to the introduction of new methods of fishing. For example, the use of pound nets and floating traps was opposed and condemned in Rhode Island and Massachusetts about 1870 (Baird, 1873) and purse seines in New Jersey beginning about 1920. Charges of destructive fishing against these gears resulted in restrictive legislation (New Jersey Board of Fish and Game Commissioners, 1936). Later, summer fishermen opposed a new winter fishery by otter trawls off the Virginia Capes (Pearson, 1932; Nesbit and Neville, 1935).

2. Occasional wholesale destruction of large numbers by predacious enemies, especially bluefish (Baird, 1873; Bigelow and Welsh, 1925).

3. Spasmodic changes in hydrographic conditions causing unusual movements of the fish and also mortalities of unusually large numbers of scup by sudden cooling of the water (Baird, 1873).

4. Annual variation in the relative success or failure of reproduction (Baird, 1873; Southwick, Root, and Morton, 1893; Nesbit and Neville, 1935).

The effects of these fluctuations in the yield of scup on the livelihood of men engaged in fishing, especially in the coastal waters of southern New England, have been of such importance as to result in special State and Federal inquiries. From 1869 to 1870, the States of Rhode Island and Massachusetts each investigated the condition of the sea fisheries along the southern coast of New England (Baird, 1873). The reports of these commissions, however, resulted in much confusion because of the difference of the findings. At the time, the principal point at issue was whether or not the "fixed apparatus" (pound nets and floating traps introduced about 1845 and widely used by 1870) was guilty of destroying "many of the fertile (spawning) fish and preventing others from depositing their eggs" (Baird, 1873). The Massachusetts committee reported "no reasonable ground for complaint" (Baird, 1873). The Rhode Island committee on the other hand, concluded that the complaint was well founded and reported in favor of a very stringent law prohibiting the further use of traps and pound nets except within a limited district (Baird, 1873). The decisions of both these committees were based largely on the testimony of the fishermen. As a result of this difference in the reports of the two commissions, Federal inquiry was made in 1871-72. The Federal commission recommended "prohibition of use of nets from Friday night until Monday morning of each week of the spawning season, and after that no restriction need be imposed," (Baird, 1873). As far as is known, no action was taken on any of these recommendations, perhaps because shortly afterwards (1872) scup became very abundant (Southwick, Root, and Morton, 1893), lending support to those who contended that protection of the species by elimination or curtailment in numbers and amount of fishing of the "fixed apparatus" was not necessary to insure successful reproduction and continued good catches.

To the present, however, opinions of those interested in the fisheries continue to differ on the causes of changes in yield and the measures necessary to make possible the best utilization of the supply. Failure to reach satisfactory agreements on these controversial problems has in the past been due, in part at least, to the lack of information on the real causes of changes in abundance and the technical difficulty of correcting wasteful and destructive practices.

It was fortunate, therefore, that in 1927, Bureau of Fisheries appropriations were made available to begin a scientific study of the shorefishes of the Middle Atlantic region for the purpose of obtaining reliable information as a basis for the wise conservation of the principal species. The study of scup has been

a part of this general investigation that began with a study of the summer inshore commercial fisheries of the Middle Atlantic and southern New England States and was subsequently extended to the summer fisheries of Virginia and also to the winter fishery offshore of the Virginia Capes. The following report comprises a description of the scup fishery, information on the life history, migrations, and causes of fluctuations in yield with recommendations for the conservation along the Atlantic coast.

RANGE

Scup (fig. 1) ranges along the eastern coast of the United States from South Carolina to Maine (Holbrook, 1855; Bigelow and Welsh, 1925). South of New York scup is commonly known as "porgy", and along the southern part of New England, as "scup".

Baird (1873) remarks as follows about the vernacular name of the scup:

> Common names: porgy; porgee; scup; scuppaug; mischup. The species has a lesser variety of names than most others belonging to our coast; . . . it is the familiar scup of scuppaug, from mish-cup-pauog of the Narragansett Indians. In the time of Roger Williams its English appellation was bream, from the resemblance to the British fish of that name.

Steindachner and Agassiz (1872) comment as follows:

> In 1621, Massasoit entertained his half-famished Puritan visitors with "two fishes, like bream, but three times so big and better meat." This was on the shore of Buzzard's Bay, and the fishes can have been nothing else than scup . . . . The Englishmen doubtless meant what is still called in Europe the "common sea-bream" whose outline is much like that of our scup.

Its greatest commercial importance is in the summer fishery from New Jersey to the southern shores of Cape Cod, Mass., and in a winter fishery from off Cape Hatteras, N.C. (lat. 35° 10' N.) to the offing of Cape May, N.J. (lat. 39° N.).

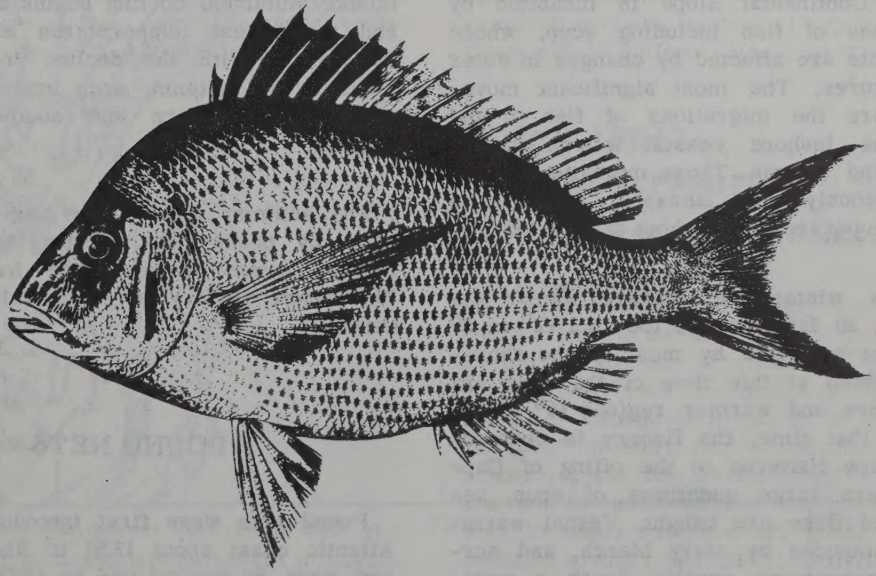


Figure 1.--Scup

In earlier times scup were caught in the greatest quantities in southern New England, especially in Rhode Island. Recently the species has become increasingly important in the southern part of its range. This has resulted principally from a remarkable rise in the summer fishery catch of New Jersey in 1929. This increase has been sustained to the present (1935). A further development in recent years has been the discovery of scup in sufficient concentration in the winter to support an increasingly important fishery (Pearson, 1932). Although for many years there had been much speculation about the winter habitat of the species (Lyman, 1872; Bigelow and Welsh, 1925), it was not until the winter of 1928 that large quantities of scup were located in the general offshore region from the offing of Cape Hatteras, N.C., northward to the offing of Cape May, N.J.

In addition to their importance in the commercial summer fishery, scup have contributed much to the catch of the large and increasing numbers of anglers from New Jersey to southern Massachusetts.

DESCRIPTION OF THE FISHERIES

The existence of distinct summer and winter fisheries for scup along the Atlantic coast is a natural consequence of seasonal changes in water temperatures. Both fisheries occur within the Middle Atlantic Bight, or that part of the Atlantic Ocean within the 100-fathom curve extending from Cape Hatteras to Cape Cod (fig. 2). This region of the Continental Slope is inhabited by populations of fish including scup, whose movements are affected by changes in water temperatures. The most significant movements are the migrations of fish to and from the inshore coastal waters in the spring and autumn. Those migrations occur simultaneously with seasonal changes in water temperature throughout this region.

In the winter, the inshore waters out to about 20 fathoms are too cool (2° to 3° C.) to be tolerated by most of the shore-fishes which at this time of the year are in offshore and warmer regions (6° to 12° C.). At that time, the fishery is centered from Cape Hatteras to the offing of Cape May where large quantities of scup, sea bass, and fluke are caught. Vernal warming commences by early March, and surface temperatures usually reach a maximum throughout the area from Cape Hatteras to Cape Cod early in August. At this time, the higher temperatures are usually inshore. With this warming, the shore species migrate from their winter habitat to inshore waters. During the spring and summer and as late as November, the fishery for scup is in the inshore waters, principally from Cape May to Rhode Island. Autumnal cooling begins by October, and the lowest temperatures are reached in March. With the decline in temperatures in the autumn, scup begin their migration to offshore and southern winter regions.

The summer fishery for scup is principally by pound nets, floating traps, otter trawls, purse seines, and handlines. The winter fishery is exclusively by otter trawls.

POUND NETS

Pound nets were first introduced on the Atlantic coast about 1850 in Rhode Island, and were in general use by 1873 from New Jersey to southern Massachusetts (True, 1887).

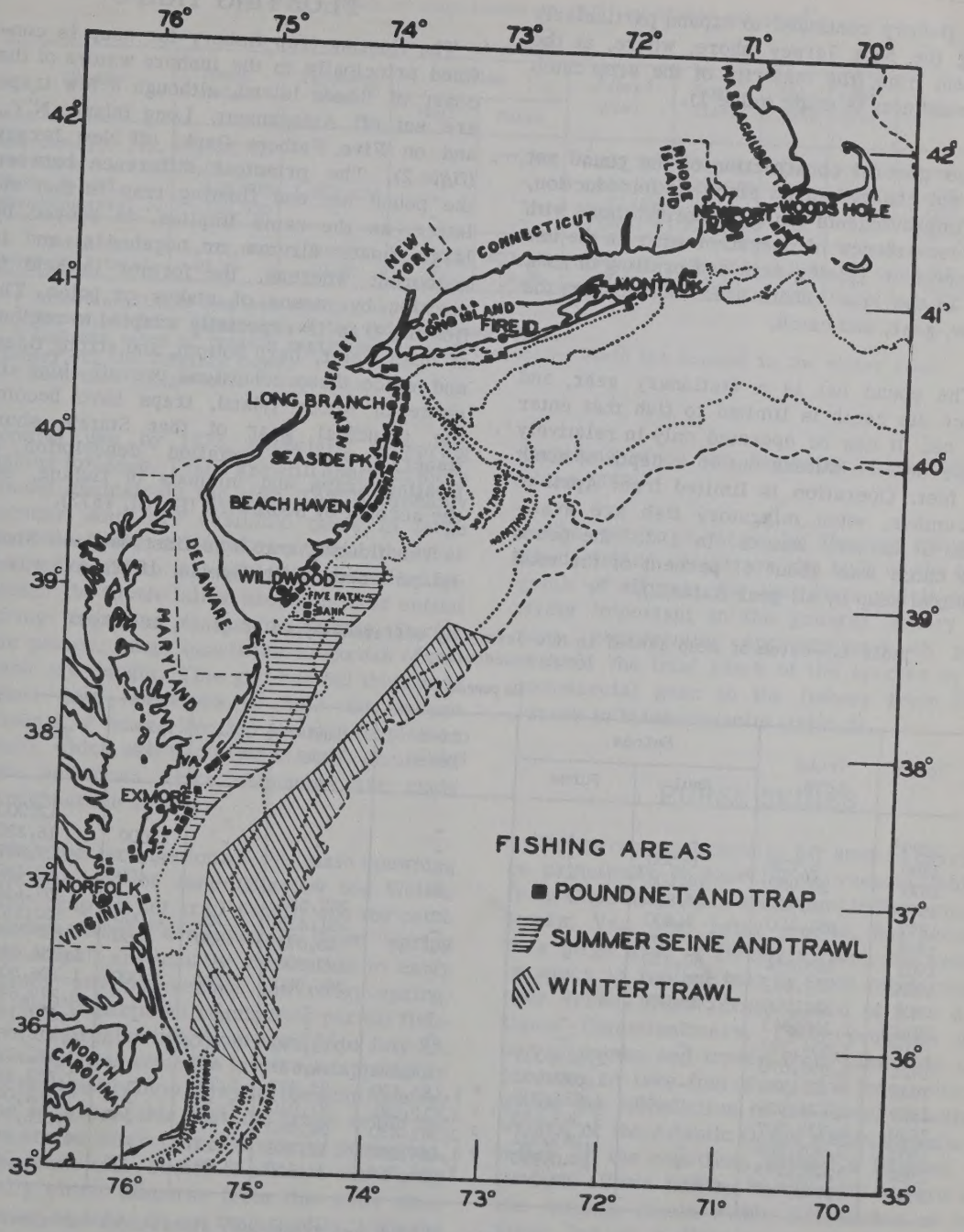


Figure 2.--Principal scup fishing areas during the early 1930's.

This fishery continued to expand particularly along the New Jersey shore, where, at the present time, the majority of the scup catch by pound nets is made (table 1).

The general construction of the pound net has not changed much since its introduction, the improvements being concerned more with the convenience of operation such as the use of power in raising nets and brailing of fish, and in the "run" boats used to transport the crew, gear, and catch.

The pound net is a stationary gear, and hence its catch is limited to fish that enter the net. It can be operated only in relatively close inshore waters out to a depth of about 60 feet. Operation is limited from April to December, when migratory fish are available in inshore waters. In 1933, the pound net catch was about 47 percent of the total catch of scup by all gear (table 2).

FLOATING TRAPS

The floating trap fishery for scup is confined principally to the inshore waters of the coast of Rhode Island, although a few traps are set off Amagansett, Long Island, N.Y., and on Five Fathom Bank, off New Jersey (fig. 2). The principal difference between the pound net and floating trap is that the latter, as the name implies, is buoyed by large floats (drums or hogsheads) and is anchored; whereas, the former is held in position by means of stakes or poles. The floating trap is especially adapted to regions of deep water, hard bottom, and strong tides; and since these conditions prevail along the shore of Rhode Island, traps have become the principal gear of that State's shore fishery. For a detailed description of floating traps and methods of fishing, see the account by Southwick (Baird, 1873).

The floating trap was first used off Rhode Island about 1850 (Lyman, 1872) and was in

Table 1.--Catch of scup landed in New Jersey by different types of gear[1], 1889-1933 (not consecutive)

[In pounds]

Years	Pound nets	Seines		Otter trawls	Hand-lines	Gill nets	Fyke nets	Total
		Haul	Purse					
1889[2]	-	-	-	-	-	-	-	12,000
1890	8,720	6,500	-	-	-	-	1,000	16,220
1891	12,982	10,600	-	-	-	-	2,100	25,682
1892	36,900	10,850	-	-	-	-	400	48,150
1897	551,100	3,800	-	-	202,550	-	-	757,450
1898	339,150	300	-	-	281,415	300	1,000	622,165
1901	385,854	[3] 80,110	-	-	140,075	900	160	607,099
1904	702,482	[3] 180,000	-	-	172,200	-	-	1,054,682
1908	324,000	[3] 583,000	-	-	286,000	500	3,000	1,196,500
1915[4]	1,226,343	-	-	-	-	-	-	3,279,693
1917[4]	1,604,393	-	-	-	-	-	-	3,673,173
1921	1,558,670	-	2,345,000	-	210,792	1,000	-	4,115,562
1926	531,343	-	1,652,400	23,311	244,425	600	-	2,452,079
1929	2,423,024	400	3,833,200	[5] 1,485,400	85,807	5,767	-	7,853,598
1930	2,733,907	-	3,343,693	[5] 1,412,081	71,010	3,350	-	7,564,041
1931	3,905,869	-	1,255,531	[5] 2,341,430	24,040	-	-	7,526,870
1932	3,482,395	-	1,440,920	[5] 1,484,250	28,301	231	-	6,436,097
1933	3,708,969	-	407,241	[5] 731,349	31,458	2,292	55	4,881,364

[1] U. S. Bureau of Fisheries (U. S. Commission of Fish and Fisheries) statistical canvasses with the exception of 1908 when canvass was made by the U. S. Bureau of the Census.
[2] Catch by gear not available.
[3] Possibly includes some catch by purse seines.
[4] Catch by gear other than pound nets not available.
[5] Includes catch by New Jersey vessels engaged in winter trawl fishing off the Virginia Capes.

Table 2.--Catch of scup landed in 1933[1] by States and gear[2]

[In pounds]

States	Pound nets	Floating traps	Seine		Otter[3] trawl	Hand-lines	Gill nets	Fyke nets	Total
			Haul	Purse					
New Jersey.....	3,708,969	-	-	407,241	731,349	31,458	2,922	55	4,881,364
New York.....	1,020,187	-	600	-	432,766	24,600	-	-	1,478,153
Rhode Island.....	123,578	1,878,853	-	-	17,000	-	-	-	2,019,431
Massachusetts....	118,932	-	-	-	1,788,178	226,300	-	-	2,133,410
Total.....	4,971,666	1,878,853	600	407,241	2,969,293	282,358	2,292	55	10,512,358
Percent of total.	47.29	17.87	.01	3.87	28.25	2.69	.02	([4])	100.0

[1] Latest available complete statistics.
[2] Report, Fishery Industries of the United States, 1934.
[3] Includes catch of vessels registered in each respective State but engaged in the winter trawl fishery off the Virginia Capes.
[4] Less than .01 percent.

general use by 1873, especially in spring fishing for scup. Traps are still operated there almost exclusively for scup. This is probably because scup are available there in large quantities only during 2 months of the year (end of April to end of June) when they approach the Rhode Island shore on their annual spring migration to inshore waters. During this period, large quantities in excess of demand are caught. This glut has led the Rhode Island trap operators to hold the excess amounts of scup alive in "pounds" (explained later), which are anchored in some sheltered cove and from which shipments are made throughout the summer.

With the termination of the main spawning about the end of June (Bigelow and Welsh, 1925), scup do not trap readily and the catch declines sharply; consequently, these "spring scup traps" are usually dismantled in early summer and put ashore until next spring. U.S. War Department regulations permit fishing in this region only from April 25 to July 25. The restriction after the latter date apparently does not greatly interfere with the scup fishery, since it is probable that the traps would not be operated after that date even if permitted, because the main bodies of market-sized scup usually either disperse from this area after June or at least do not trap readily. Like the pound nets, the floating traps have not undergone much change in construction, the improvements being confined to easier and quicker operation by the use of power. The majority of the traps have been set on the same locations since the beginning of the fishery about 1850.

The catch of scup by floating traps in Rhode Island comprises the bulk of the total catch of all gear for that State and is relatively important in the general fishery for scup, representing approximately 18 percent of the total catch of the species by all commercial gear in the fishery from New Jersey to Massachusetts (table 2).

PURSE SEINES

The purse seine fishery for scup is carried on principally by New Jersey vessels fishing from Cape May, N.J., southward to Parramore Banks, Va., and, being mobile, has access to a large area of fishing ground, the extent of which is limited only by State regulations. New Jersey (New Jersey Board of Fish and Game Commissioners, 1936) prohibits the use of seines and trawls from taking or attempting to take fish of any kind from waters within the jurisdiction of the State, including waters of the Atlantic Ocean within 3 nautical miles of the coastline, without a license. A license allows fish to be taken in waters of the Atlantic Ocean within jurisdiction of the State, but at a distance of not less than 2 miles from the coast. Virginia (1936) also prohibits the use of purse seines and otter trawls except under special conditions in certain territorial waters of the State. New York (New York Conservation Department,

1936) regulations affect the catches of purse seine and otter trawlers to a lesser extent, because restriction applies only to certain small areas relatively unimportant as commercial fishing grounds.

In contrast to proud nets and floating traps, the purse seine fishery for scup is a comparatively recent development. Although the purse seine has long been in use as an effective apparatus for catching schooling fish, it was not until about 1920 that this gear came into prominence in the scup fishery. Its use resulted mainly from the development about that time of motorized boats capable of making quick trips to and from distant fishing locations. Thus, fishermen were able to operate offshore in seasons when the market value of fish was high. Because the southern New Jersey ports offer good harbors and are convenient both to the offshore fishing grounds and to good markets, they became a center for the purse seine fishery. From these New Jersey ports, purse seiners fish throughout the summer for shore species, which are most readily available or have the highest market value.

From 1930 to 1935, purse seines have produced a relatively small part of the total yield of scup along the Atlantic coast (table 2). During recent years the reported landings of this species have been much less than the actual catches, because quantities of fish have been discarded at sea. This discarding often occurs during periods of unusual abundance that have prevailed along the New Jersey coast in recent years. Furthermore, landing reports do not always include the total possible catch, since fishermen may pass up schools of scup in search for more profitable species. In the New Jersey summer fishery for scup, however, the purse seine catch is relatively important, being exceeded only by that of pound nets (tables 1 and 2).

OTTER TRAWLS

The otter trawl fishery for scup is the only year-round fishery for this species because this gear is effective in the winter when other gear fails to catch this fish. The catch by otter trawls in recent years accounts for approximately 28 percent of the total yield (table 2). The relative importance of this gear is a recent development, for prior to 1929 the catch by otter trawls was insignificant and was confined to the summer season.

With the development of a winter trawl fishery about 1929 and its rapid expansion in later years, the catch increased greatly. The winter and summer trawl fisheries, however, are not only markedly different in the amount of catch, but also in locality of fishery, size of fleet, and kinds of fish caught in addition to scup.

The summer otter trawl fishery for scup is conducted principally by New Jersey vessels operating in inshore waters (about 5 to 40 fathoms) off Cape May, N.J., and Cape Henlopen, Del. Its development began about 1926, a natural outgrowth from flounder "dragging". In the winter in inshore waters, small boats "dragged" (and still do) for winter flounders (*Pseudopleuronectes americanus*, Walbaum) and in the summer, for fluke (*Paralichtys dentatus*, Linnaeus). In recent summers (1935-36), fishermen using small otter trawl along the inshore waters (out to 20 fathoms) of Fire Island, N.Y., have turned more toward the catching of scup. This diversion resulted from a scarcity of fluke and the knowledge that scup can be caught by the so-called "balloon net" as distinguished from the so-called "flat net" commonly used for fluke. The efficiency of the balloon net in catching scup has been demonstrated by the success of the southern winter trawl fishery, which uses the net almost exclusively for such species as scup and sea bass. It is probable that the summer otter trawl fishery for scup will increase in coming years in other parts of the range of the species.

At the beginning, the fleet consisted of comparatively small powered boats (25-50 feet) that, because of their size, were restricted to fishing close to shore (not beyond

15–25 miles). As the fishery developed, larger and more powerful boats were added to the fleet. Many of these were diesel-powered, capable of fishing farther offshore and of taking large catches on trips of long duration. This summer fleet fished mainly for fluke, so that the occasional good catches of scup were only incidental. Hence, prior to 1929, the summer catch of otter trawls contributed relatively little to the total catch of scup of the Atlantic States (fig. 3). Since 1929, the summer trawl catch of scup has increased mainly because of improved fishing methods and also, as will be shown later, because of increased abundance along the New Jersey coast.

The activity of this fleet is still directed primarily for fluke, which has a higher market value than scup. Hence, the present summer catch of scup by otter trawls is still relatively small. Although complete records are not available, it is estimated that this summer trawl fishery in 1933 accounted for only 27 percent of the total yield by this gear (summer and winter) from New Jersey to Massachusetts and only approximately 8 percent of the total catch by all gear for New Jersey alone.

The winter trawl fishery for scup is confined principally to the general offshore regions in depths from 20 to 100 fathoms from the offing of Cape May, N.J., to Cape Hatteras, N.C. (fig. 2). The development of this fishery is one of the most important features in the history of the industry, principally because it has resulted in the discovery of commercial quantities of scup (as well as fluke, sea bass, and croakers) in a winter habitat, the location of which for years was the subject of much speculation (Baird, 1873; Bigelow and Welsh, 1925). Because of increasing activity and amount of catch, this new branch of the industry has added much to economic and conservation problems (Pearson, 1932; Nesbit and Neville, 1935).

The development of this fishery, like that of the summer trawl fishery, was an outgrowth of flounder dragging (Pearson, 1932). About 1920 New Jersey "fluke draggers" were first attracted to the more inshore and southern part of the winter fishery region, especially along the Virginia and North Carolina coasts in their search for fluke and croakers. The New Jersey boats went south in the spring to intercept the schools of fish migrating to inshore areas and in the autumn followed the fish south from New Jersey waters when the species began their return migration to more southern regions. The fleet at that time consisted mainly of small, low-powered boats that formed the summer dragger fleet of southern New Jersey. The vessels became so numerous that Virginia and North Carolina, seeking to protect their extensive inshore pound net and haul seine fisheries, passed laws in 1926 and 1930 prohibiting all trawling in State-controlled waters including the lower Chesapeake Bay.

The Virginia law was changed in 1936 to provide that no trawling should be done in any territorial waters of the State, except from a point about 10 miles south of Cape Henry Lighthouse to the North Carolina State line during the months of February, March, April, and May of any year and only then by holders of a license for which a fee of $25 is required. Only residents of Virginia are eligible to receive these licenses (Virginia, 1936).

Perhaps as a result of this, the larger and more powerfully equipped vessels gradually ventured offshore and finally located commercial quantities of such typical summer fish as scup, sea bass, and fluke in the deeper water 30 to 50 miles off the Virginia coast. This rather startling discovery of at least part of the winter habitat of summer fishes led to the establishment of a new fishery.

In the winter of 1928–29, several New England vessels equipped for dragging in the deeper water went south and fished regularly in the offshore region. They were so successful that in the following winter they were joined by other vessels. As a result, each winter has seen an increasing number

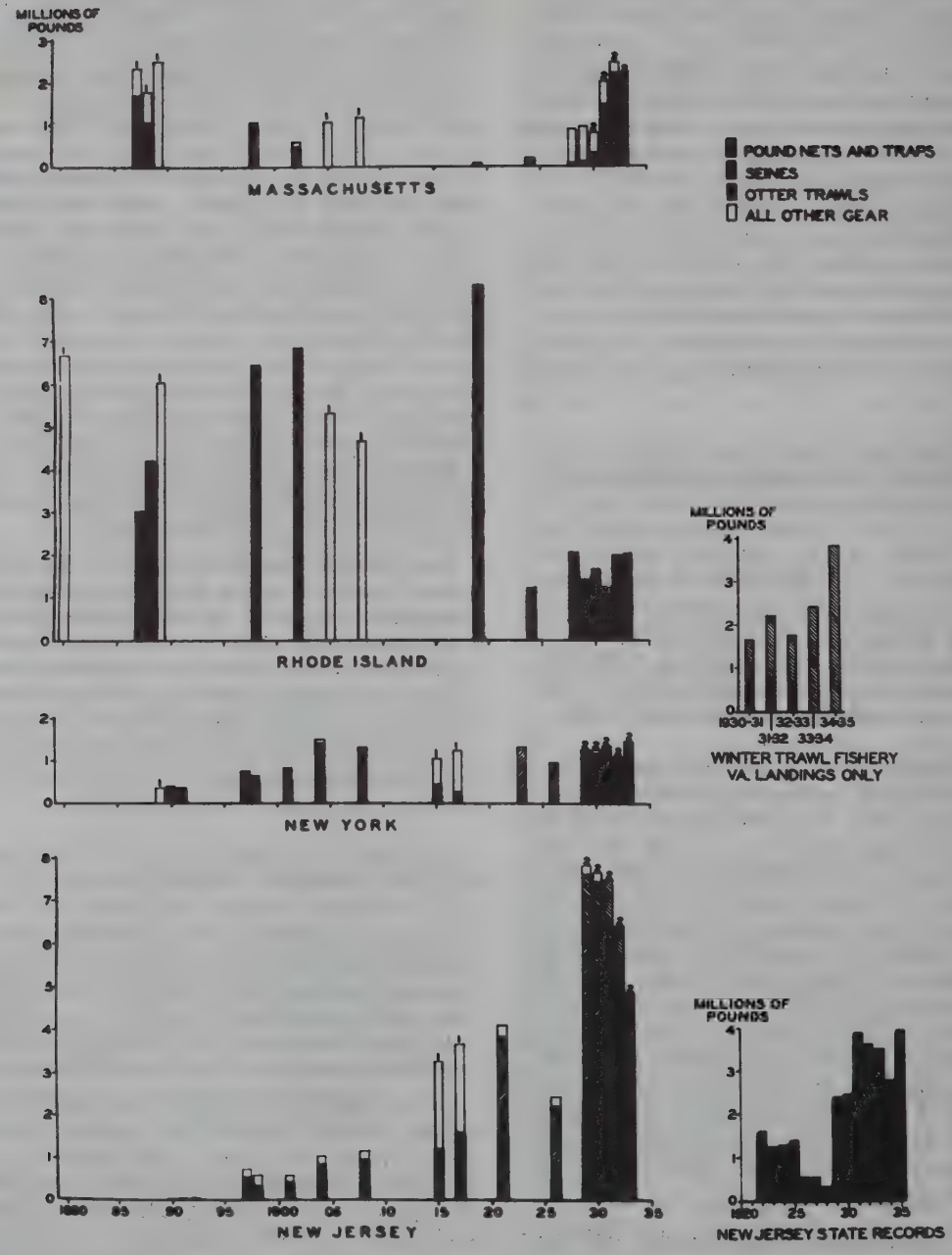


Figure 3.--Catch of scup in pounds landed by States and gear.

of boats, and by the winter of 1935, over 100 vessels were engaged in this new fishery (Nesbit and Neville, 1935).

The present fleet has largely high-powered, sturdy vessels equipped for fishing any part of the region from Cape Hatteras to Cape Cod and in depths out to about 80 fathoms. Most of the winter trawlers land their catches at Virginia ports, namely: Norfolk, Phoebus, and Portsmouth. A smaller part of the fleet lands its fares at Cape May and Wildwood, N.J.; and in the more recent winters, an increasing number at New York, N.Y.

The landings of this winter fishery have increased so rapidly since its inception in 1929 that the catch now amounts to approximately 73 percent of the total yield of scup by otter trawls from New Jersey to Massachusetts and approximately 20 percent of the catch by all gear.

HANDLINES

Commercial and sport handline fishing for scup is carried on along various sections of the coast. An important commercial fishery is centered at Wildwood, N.J., where a fleet of small boats fishes, in addition to scup, for squeteague, sea bass, and bluefish. Some fishing is also done in the vicinity of Montauk, N.Y., and Woods Hole, Mass., principally for scup, sea bass, and fluke. The best handline fishing is usually in August, September, and October, after the main spawning season is over, since scup do not take the hook readily during the spawning season.

The catch by commercial handliners was an important part of the total yield of all gear in early days, but in late years, with the development of more efficient methods of fishing, the handline catch has diminished to insignificant proportions compared to other forms of gear.

In recent years, salt-water angling has markedly increased, especially along the shores of New York and New Jersey. Although complete records of catch by anglers are not available, it is believed, on the basis of a few reports, that this catch must amount to surprisingly large quantities of fish and in some localities even exceeds the catch by the local commercial gear. It was not possible to cover this sport fishery in this study. Catch records of both the commercial handliner and angling fisheries have been omitted from further discussion, because the data are incomplete and otherwise unsuitable for explaining changes in yield.

FLUCTUATIONS IN YIELD AND THEIR CAUSES

In the following discussion of the fluctuations in yield of scup, the summer fishery will be treated separately from the winter fishery because of the differences in the kind of gear, the locality of the catch, and the quantity of catch. Also, there is the possibility, indicated by results of tagging experiments, that certain parts of the summer fishery draw on separate population units, which are available to the winter fishery because of migrations to a common winter habitat. In addition, it is desirable to divide the summer fishery into a New Jersey fishery and a New York–southern New England fishery because the fisheries in these two localities also differ in the type of gear used, the length of season, the quantity, size, and age composition of the catch, and also because of the possibility that each fishery draws on separate population units.

Total annual landings of scup were determined for various years between 1879 and 1933, as a result of periodic canvasses by

the Bureau of Fisheries and of annual pound net catch statistics by the States. The States were often surveyed in different years so that the catches in each State are not always available every year. For this reason the changes in total yield of each State will be discussed separately.

SUMMER FISHERY

Statistics of the Fishery, New Jersey

Changes in total yield.--It is evident that the total yield has undergone major fluctuations (table 1). The data do not, however, reveal reliable information on the changes in gear, either as to amount or type; and since these often are a principal cause of changes in catch, the lack of accurate records of gear injects some doubt and difficulty in interpreting the changes in yield in terms of changes in abundance. In addition, the records of catch are subject to some inaccuracy because many of the data, especially in the earlier years of the Bureau's canvasses, were obtained from operators who lacked written records and based their figures on memory. Nevertheless, it is believed that the Bureau's statistics, though not revealing the absolute values of the changes in the yield, are sufficiently reliable to reveal major changes that have occurred.

The catch of scup in New Jersey by the three principal types of gear (pound nets, otter trawls, purse seines) was small from 1890 to 1892. It increased beginning in 1897, reached a peak in 1929, and remained high to 1933. From 1890 to about 1908, the fishery expanded, mainly by increases in numbers of ocean pound nets, especially in the southern and later in the central seaboard counties of the State. Since 1908, the number of these nets has remained about the same although there have been minor changes from year to year. Other changes in gear resulting in an increase in the catch were the expansion of the purse seine fishery about 1920 and the otter trawl fishery (especially in the winter) beginning in 1929.

Measurement of fluctuations.--In the present study, the pound net fishery in New Jersey has been chosen for an analysis of changes in abundance because it produces the most important part of the total yield of scup and provides a convenient unit for measuring the relative abundance and availability of the fish. There were certain factors that made it difficult to obtain from these pound net records a clear understanding of the causes of fluctuations in the yield. These included changes in availability by erratic movements of fish, the lack of accurate and complete records of the quantities of small fish discarded at sea in times of unusual abundance and low market, and changes in fishing effort through destruction of gear or curtailment of fishing during storms. Few operators kept written accounts of the storm periods and of the number of nets destroyed or damaged. Changes in the amount of fishing also occurred when fouled nets were changed at different times of the season by being removed completely from the water, or, as in some districts, by being hung on the pound-poles to dry for a few days. Few records contained notations of the actual number of nets fishing during such periods of drying or changing gear.

Despite these influencing factors, a unit of measure termed the catch per trap per season was computed. This unit represents the number of pounds of scup caught by an average trap in one season. In the analysis of the causes of changes in the catch of the stationary gear, the term "trap" will be used to refer to both pound nets and floating traps, because both gears are fundamentally the same in construction and operation, and changes in their catches are affected by the same or similar causes. The measure was fairly indicative of changes in abundance or in availability and could be used for showing relative changes in yield of the pound net fishery of New Jersey. This gear produced most of the catch in the State; therefore, its catch reflected the major changes in total yield.

In the study of changes in the catch per trap per season, data were available from two sources: (1) Annual reports of the New Jersey Board of Fish and Game Commissioners, showing the gross catch of each species and the average number of nets fished during the season; and (2) operators' private records of daily catch and number of nets fished.

The catch per trap was used instead of catch per lift because the State records on which we depended for earlier years recorded only the number of nets fished and had no record of number of lifts (table 3). All the nets in operation were not always lifted the same day, so that the catch per lift may or may not have represented one or more days' fishing; further, a net fishing 2 days for instance without being lifted the first day did not necessarily catch twice as much as a net lifted after only 1 day's fishing.

The analysis of changes on the basis of catch per trap is limited to the period 1922-35 inclusive, because detailed records for earlier years are not available. From a relatively high yield in 1925, the catch per trap declined to a low level in 1928 but recovered quickly to a record high in 1929 with continued high yields until 1935. Since these changes were measured by the same unit yardstick for all years, the fluctuations in catch were, therefore, the result not of any increase in nets but of either changes in availability or abundance, or a combination of both. Admittedly, all parts of the New Jersey coast did not experience the same fluctuations at exactly the same time as shown. This can be seen in table 4 and figure 4 in which the catch per trap for various areas is given. The catch per trap at Wildwood was comparatively high in 1928. Also the increase in catch was apparent at Beach Haven in 1931 compared to that in 1929 at Long Branch. The difference at Wildwood possibly occurred because at that point catches were from traps set on Five Fathom Bank, some 10 miles offshore, and are not strictly comparable with catches made in more inshore areas at Beach Haven and Long Branch. The fact remains, however, that at most points in New Jersey, the trend of catch from 1925 to 1935 was similar. In 1933 and 1934 considerable quantities of scup were dumped overboard by pound net operators because the market was glutted. Thus, the reported catch for those years is less than the catch actually made by an undetermined amount of discarded fish.

Table 3.--Catch of scup in New Jersey pound nets and average catch per net, 1922-35[1]

Years	Total catch	Nets (traps)	Catch per net
	Pounds	*Number*	*Pounds*
1922	1,601,244	149	10,747
1923	1,284,489	135	9,515
1924	1,295,441	130	9,965
1925	1,404,680	119	11,804
1926	543,242	126	4,511
1927	545,365	113	4,809
1928	316,654	106	2,987
1929	2,400,043	116	20,630
1930	2,467,206	104	23,723
1931	3,905,869	128	30,515
1932	3,689,127	118	31,264
1933	3,539,041	102	34,696
1934	2,849,066	92	30,968
1935	3,924,451	102	38,475

[1] Based on annual reports to the State by licensed pound net operators.

Causes of changes in yields.--What caused these changes in yield? We know that changes in the migratory habits of fish often cause the catch to fluctuate; therefore, it might be assumed that such a change in availability may have caused the decrease in catch from 1926 to 1928. If this had been the case, however, it was to be expected that a large body of fish may have moved away from the pound net region in 1926 to more offshore areas. If such occurred, they should have been available to the offshore vessel fishery, and good catches should have been made by such gear as purse seines. It is also possible that the fish may have migrated in 1926 from New Jersey waters to other localities (south or north New Jersey), causing a rise in the catch of scup at those points between 1926 and 1928. From available records there was no evidence that either the vessel catch increased significantly between 1926 and 1928 or that unusual increases occurred at other points along the coast. Furthermore, there are no records of marked changes in the hydrography in the region from one summer to another during the period studied (Parr, 1933), and, hence, there seems to be no reason to suppose that the fish had migrated away from inshore New Jersey waters.

Table 4.--Average catch of scup per trap along the Atlantic coast, 1921-34[1]

[In pounds]

Years	New Jersey[2]					New York[2]		Rhode Island[3]	Massachusetts[2]
	Wildwood[4]	Beach Haven	Seaside Park	Bay Head	Long Branch	Fire Island	Montauk	Newport	Woods Hole
1921	([5])	15,860	7,120	25,340	([5])	([5])	([5])	([5])	10,250
1922	35,100	8,020	2,340	7,100	[6] 2,460	([5])	420	24,520	9,040
1923	14,960	24,660	6,440	4,500	[6] 10,440	([5])	540	12,660	9,600
1924	18,040	24,820	7,040	7,560	[6] 15,020	([5])	820	24,980	1,840
1925	3,280	8,840	[6] 2,226	19,060	[6] 17,300	3,540	300	33,180	34,340
1926	1,200	2,020	[6] 3,800	2,480	[6] 2,820	5,420	800	19,780	15,200
1927	5,760	1,480	[6] 7,800	2,420	[6] 8,180	4,660	920	13,060	43,160
1928	10,060	5,060	840	1,840	1,120	8,280	500	33,760	6,160
1929	9,780	9,340	42,640	22,420	42,380	13,840	13,780	28,420	5,960
1930	13,740	25,560	25,800	13,080	15,640	16,520	2,380	41,940	25,620
1931	23,860	58,620	39,580	21,420	44,840	48,500	2,640	40,660	19,180
1932	10,300	32,260	23,440	24,460	44,000	51,320	2,640	123,000	11,560
1933	[7] 3,380	31,500	56,220	32,740	55,640	101,940	7,880	149,400	12,380
1934	39,260	41,560	43,400	20,980	25,440	62,780	6,220	102,600	7,080

[1] Based on combined private records of operators.
[2] By pound nets.
[3] By floating traps.
[4] Includes Five Fathom Bank traps.
[5] Not available.
[6] From annual reports to Division of Fish and Game, State of New Jersey.
[7] Some Five Fathom Bank traps not set in 1933.

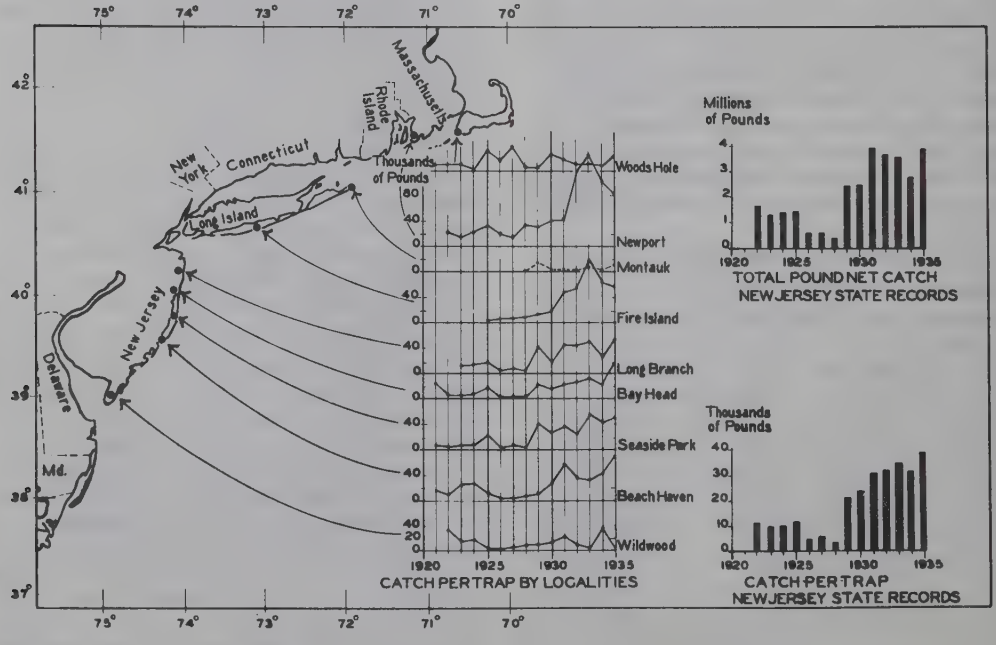


Figure 4.--Catch per trap of scup along the Atlantic coast, 1921-34.

The question then is whether or not these changes reflect the abundance of the total population or of the individual year classes which comprised the catch. This question may be answered by studying the size and age composition of the catches. To do this the population was sampled as follows: Random samples of about 100 fish per catch were measured from as many catches as possible throughout the season. These measurements, when tabulated, fell into certain size groups that were indicative of age, at least to the fourth summer. Because of the overlapping of measurements of the older and larger fish, lengths of fish five summers and older were grouped and treated as a single unit. This appeared permissible since the life span of the scup in the commercial fishery is relatively short, the greater part of the catch being composed of 2- to 4-year-old fish in varying proportions, while fish over 5 years of age composed relatively less of the catch.

To insure reliability in interpretation of age by this method, it is necessary that there be a fairly continuous series of measurements of fish from postlarval sizes to the largest size present in the commercial fishery. Fishermen discard fish less than about 7 inches in length, so special arrangements were made to obtain fish below this limit. For sizes immediately below the legal or market limit, samples were obtained from the commercial catches before discarding took place or from 1- or 2-bushel lots of unsorted fish brought in at various times by cooperative fishermen.

Samples of fish from the smallest sizes (approximately 11 cm. or 4.5 inches) caught by pound nets down to and including postlarval sizes were obtained by dip nets in the vicinity of pound nets during June and July, when spawning scup constitute a large part of the catch. Along the Middle Atlantic and southern New England coast, spawning occurs mainly in May and June and part of July according to Bigelow and Welsh (1925). Small-mesh seines and otter trawls were used along the beach and in the deeper water of small inlets from middle of July to end of October. The smallest fish were caught with these gears in July 1929 when the length mode of scup caught with dip net was 1 cm. Others caught with beach seines averaged about 4.5 cm. (fig. 5, table 5). The difference in sizes caught by these gears may reflect the efficiency of capture by each type of gear. The two sizes begin to merge in August, and during September when captures were made by seine only, the fish caught had grown to an average

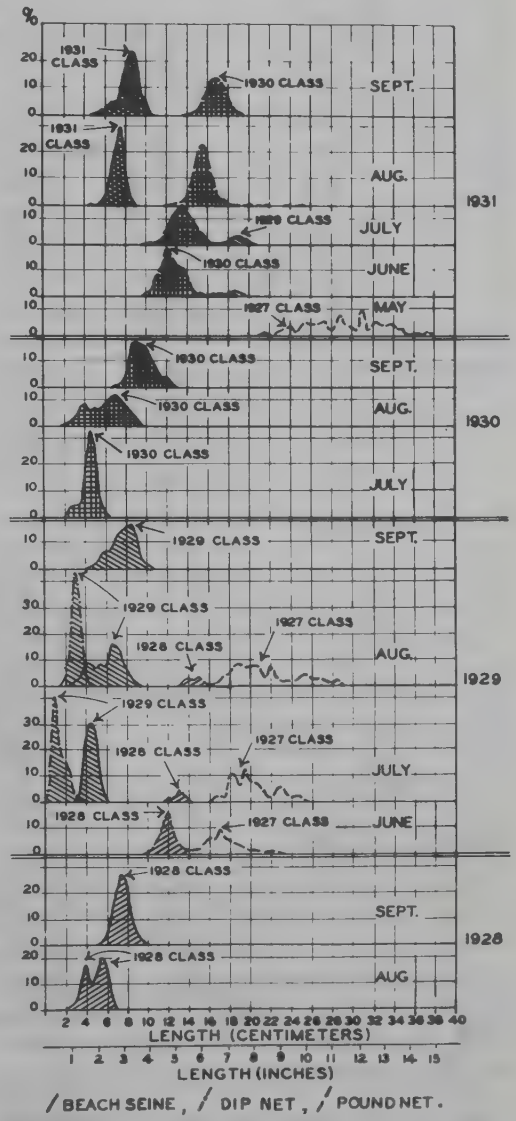


Figure 5.--Length composition in percent of scup caught by experimental and commercial gear, 1928-31.

Table 5.--Length frequencies in random samples of scup from catch by experimental and commercial gear, 1928-31

[Numbers of fish]

Length	1928		1929								1930			1931							
	Aug.	Sept.	June	July			Aug.			Sept.	July	Aug.	Sept.	May	June	July	Aug.		Sept.		
	Seine	Seine	Pound net	Dip net	Seine	Pound net	Dip net	Seine	Pound net	Seine	Seine	Seine	Seine	Pound net	Pound net	Pound net	Seine	Pound net	Seine	Pound net	
Cm.																					
.5	-	-	-	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1.0	-	-	-	222	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1.5	-	-	-	109	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2.0	-	-	-	82	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	
2.5	2	-	-	65	-	-	13	2	-	-	5	2	-	-	-	-	-	-	-	-	
3.0	8	-	-	12	-	-	45	7	-	-	6	22	-	-	-	-	-	-	-	-	
3.5	29	-	-	2	4	-	34	16	-	-	6	43	-	-	-	-	-	-	-	-	
4.0	53	-	-	3	19	-	5	39	-	-	22	48	-	-	-	-	-	-	-	-	
4.5	29	-	-	-	22	-	-	36	-	3	44	33	-	-	-	-	2	-	-	-	
5.0	38	-	-	-	19	-	-	27	-	5	35	39	-	-	-	-	-	-	-	-	
5.5	61	1	-	-	6	-	-	34	-	16	7	36	-	-	-	-	1	-	1	1	
6.0	54	2	-	-	1	-	-	29	-	21	1	51	-	-	-	-	18	-	5	14	
6.5	21	8	-	-	-	-	-	67	-	19	-	64	-	-	-	-	52	-	28	7	
7.0	-	13	-	-	-	-	-	63	-	39	-	68	1	-	-	-	117	-	8	25	
7.5	-	20	-	-	-	-	-	53	-	45	-	58	2	-	-	-	123	-	73	22	
8.0	-	18	-	-	-	-	-	23	-	49	-	43	22	-	-	-	49	-	97	16	
8.5	-	7	-	-	-	-	-	12	-	52	-	29	63	-	-	-	15	-	138	7	
9.0	-	3	-	-	-	-	-	2	-	41	-	13	66	-	-	-	3	-	121	5	
9.5	-	1	-	-	-	-	-	-	-	10	-	1	62	-	-	-	-	-	48	1	
10.0	-	-	1	-	-	-	-	-	-	6	-	-	59	-	3	1	-	-	18	-	
10.5	-	-	7	-	-	-	-	-	-	-	-	-	42	-	3	3	-	-	-	-	
11.0	-	-	25	-	-	-	-	-	-	-	-	-	23	-	12	5	-	-	-	-	
11.5	-	-	35	-	-	-	-	-	-	-	-	-	14	-	19	8	-	-	-	-	
12.0	-	-	60	-	-	1	-	-	-	-	-	-	16	-	22	29	-	-	-	-	
12.5	-	-	32	-	-	1	-	-	-	-	-	-	4	-	23	42	-	2	-	-	
13.0	-	-	13	-	-	3	-	-	-	-	-	-	-	-	12	57	-	7	-	-	
13.5	-	-	7	-	-	2	-	-	1	-	-	-	-	-	11	67	-	7	-	-	
14.0	-	-	3	-	-	-	-	-	4	-	-	-	-	-	8	57	-	29	-	-	
14.5	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	44	-	76	-	1	
15.0	-	-	6	-	-	-	-	-	4	-	-	-	-	-	1	29	-	138	-	2	
15.5	-	-	12	-	-	-	-	-	1	-	-	-	-	-	-	18	-	159	-	12	
16.0	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	4	-	124	-	26	
16.5	-	-	18	-	-	1	-	-	-	-	-	-	-	-	-	1	-	68	-	63	
17.0	-	-	34	-	-	2	-	-	1	-	-	-	-	-	-	3	-	15	-	52	
17.5	-	-	21	-	-	1	-	-	5	-	-	-	-	-	1	3	-	16	-	41	
18.0	-	-	19	-	-	7	-	-	5	-	-	-	-	-	1	7	-	3	-	9	
18.5	-	-	14	-	-	7	-	-	10	-	-	-	-	-	2	14	-	2	-	6	
19.0	-	-	5	-	-	4	-	-	11	-	-	-	-	-	-	14	-	2	-	1	
19.5	-	-	8	-	-	9	-	-	8	-	-	-	-	-	-	9	-	3	-	1	
20.0	-	-	6	-	-	5	-	-	9	-	-	-	-	-	-	5	-	5	-	-	
20.5	-	-	4	-	-	5	-	-	9	-	-	-	-	-	-	2	-	2	-	-	
21.0	-	-	2	-	-	4	-	-	9	-	-	-	-	-	-	-	-	-	-	-	
21.5	-	-	3	-	-	2	-	-	3	-	-	-	-	2	-	-	-	-	-	-	
22.0	-	-	-	-	-	1	-	-	10	-	-	-	-	-	-	-	-	-	-	-	
22.5	-	-	1	-	-	3	-	-	4	-	-	-	-	-	-	2	-	-	-	-	
23.0	-	-	-	-	-	4	-	-	1	-	-	-	-	2	-	-	-	-	-	-	
23.5	-	-	2	-	-	2	-	-	2	-	-	-	-	3	-	-	-	1	-	-	
24.0	-	-	-	-	-	1	-	-	1	-	-	-	-	4	-	-	-	-	-	-	
24.5	-	-	-	-	-	2	-	-	1	-	-	-	-	1	-	-	-	-	-	-	
25.0	-	-	-	-	-	1	-	-	4	-	-	-	-	4	-	-	-	1	-	-	
25.5	-	-	-	-	-	-	-	-	6	-	-	-	-	7	-	-	-	-	-	-	
26.0	-	-	-	-	-	-	-	-	3	-	-	-	-	5	-	-	-	-	-	-	
26.5	-	-	-	-	-	-	-	-	3	-	-	-	-	5	-	-	-	-	-	-	
27.0	-	-	-	-	-	-	-	-	3	-	-	-	-	6	-	-	-	-	-	-	
27.5	-	-	-	-	-	-	-	-	2	-	-	-	-	7	-	-	-	-	-	-	
28.0	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	
28.5	-	-	-	-	-	-	-	-	3	-	-	-	-	4	-	-	-	-	-	-	
29.0	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	
29.5	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	
30.0	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	
30.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
31.0	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	
31.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
32.0	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	
32.5	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	
33.0	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	
33.5	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	
34.0	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	
34.5	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	
36.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
37.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
38.0	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	
Total	295	73	359	531	71	68	98	410	126	306	126	551	374	119	119	424	380	661	537	312	

length of about 8.5 cm. Similarly, the samples from the 1930 year class in 1930 showed a growth from about 4.5 cm. in July to about 9 cm. in September.

Following the 1930 year class through the second summer (fig. 5, 1931), the modal value progresses from 12 cm. in June to about 16.5 cm. in September. Thus, it was possible to follow the growth of scup from the small sizes up to the marketable sizes. Applying the same procedure of analysis to the commercial data (fig. 6, tables 6 and 7), we traced the growth of separate broods up to the end of the fourth summer (about 24.5 cm. or 9.6 inches). Beyond that it was difficult to determine age from the length frequency distributions because of the overlapping of age groups. This method of

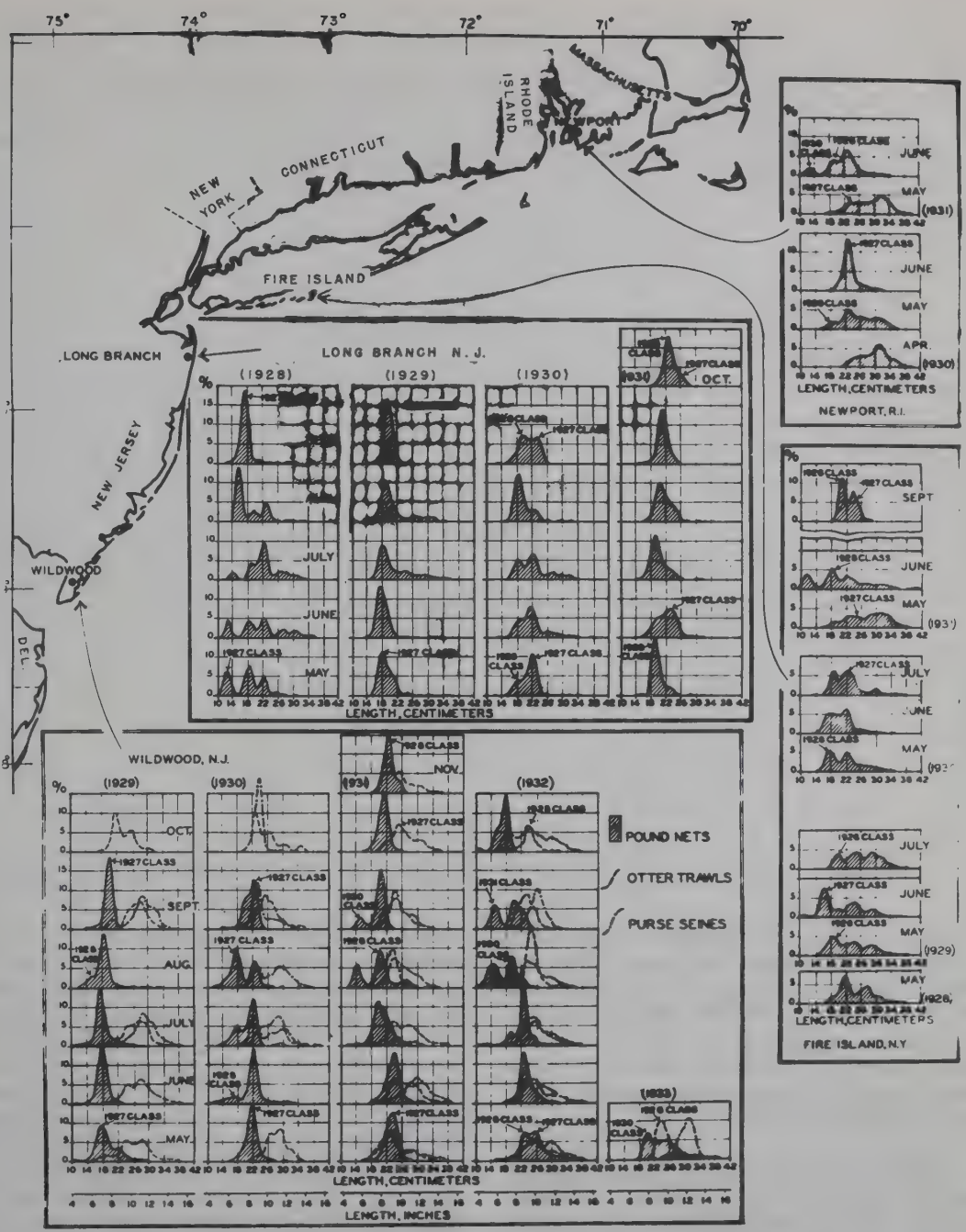


Figure 6.--Length composition in percent from random sampling of the summer fishery--mostly from pound net catches, 1928-33.

Table 6.--Length frequencies of scup in random samples from catch by pound nets in the vicinity of Long Branch, N. J., 1928-31

[Numbers of fish]

Length	1928					1929					1930					1931					
	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	Oct.
Cm.																					
11.0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11.5	8	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.0	5	10	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-
12.5	14	25	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-
13.0	10	25	3	-	1	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-
13.5	4	11	8	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14.0	5	6	6	1	-	-	-	2	2	1	-	2	-	-	-	-	-	1	-	-	-
14.5	-	3	6	2	3	-	-	-	1	1	-	1	-	-	-	-	-	1	-	-	-
15.0	1	-	2	7	4	-	-	-	-	1	2	-	-	-	-	-	-	1	-	-	-
15.5	-	-	-	11	11	-	1	1	4	-	3	-	-	-	-	1	-	3	1	1	-
16.0	-	2	-	8	10	3	24	2	2	2	2	3	1	3	2	1	1	2	-	-	1
16.5	2	4	-	8	27	7	31	21	4	1	8	6	3	3	2	-	5	2	1	2	1
17.0	4	9	1	4	48	9	39	25	8	2	9	13	12	12	2	-	5	7	3	2	-
17.5	10	16	4	-	50	18	41	58	24	3	16	18	13	36	3	-	11	20	4	-	-
18.0	8	21	13	-	28	21	35	47	45	16	22	17	12	26	1	3	22	18	7	-	-
18.5	15	20	14	3	16	17	30	46	63	22	11	20	20	36	4	12	26	35	8	6	1
19.0	7	22	16	3	7	5	26	33	40	49	14	22	13	34	9	19	31	40	27	3	1
19.5	1	9	10	1	4	15	17	29	52	49	19	15	11	18	9	17	35	55	19	6	2
20.0	3	7	7	6	-	6	9	30	35	42	14	19	10	12	8	12	35	44	50	23	1
20.5	4	10	15	-	4	9	8	7	27	29	13	19	6	10	4	12	35	30	52	35	6
21.0	2	10	16	-	2	5	3	12	8	16	28	38	10	6	11	6	38	19	47	37	8
21.5	9	19	20	3	1	9	1	13	17	13	45	38	23	2	6	4	48	16	30	57	10
22.0	7	26	40	3	1	1	1	12	7	3	46	36	17	14	5	2	37	11	25	27	19
22.5	7	15	26	6	-	1	-	7	9	-	49	30	24	6	5	2	49	15	29	30	35
23.0	2	17	15	7	2	-	-	11	2	-	32	20	18	6	11	2	71	13	24	18	33
23.5	2	9	8	1	-	1	-	11	5	1	17	16	10	10	6	3	41	7	20	8	19
24.0	-	3	5	2	-	-	2	16	3	-	11	5	6	3	8	2	52	7	22	6	13
24.5	1	1	5	-	1	3	1	13	4	-	6	2	1	1	5	1	50	10	20	6	10
25.0	2	1	5	-	-	2	-	7	7	2	6	6	3	-	4	-	40	1	16	5	13
25.5	-	5	5	-	-	-	1	8	7	-	3	5	6	-	-	-	26	2	11	2	4
26.0	-	7	10	1	-	-	-	5	1	-	1	12	3	2	-	-	5	1	6	1	8
26.5	-	6	8	-	-	1	-	7	8	-	2	6	4	2	-	-	7	-	2	-	5
27.0	-	14	1	-	1	-	1	9	7	-	-	6	6	-	-	-	4	-	-	-	8
27.5	1	11	6	-	-	-	-	4	5	-	-	2	7	-	-	-	6	-	1	-	-
28.0	-	5	8	1	-	1	-	7	4	-	1	6	5	1	-	-	4	-	1	-	-
28.5	-	3	2	-	1	-	-	7	3	-	-	6	7	1	-	1	3	-	-	-	-
29.0	-	3	2	-	1	-	-	10	7	-	-	4	4	1	-	-	4	-	-	-	-
29.5	-	8	4	1	-	1	-	5	4	-	-	6	5	2	-	-	2	-	-	-	-
30.0	-	10	5	-	-	1	-	8	8	-	1	1	6	2	-	-	1	1	-	-	-
30.5	-	6	2	-	1	-	-	3	4	-	1	1	2	-	-	-	-	-	2	-	-
31.0	-	7	2	-	1	-	-	3	5	1	1	4	3	1	-	-	4	-	-	-	-
31.5	-	7	4	-	-	-	-	6	7	-	2	2	4	-	-	-	1	1	-	-	-
32.0	-	3	-	1	-	-	-	3	3	-	-	1	4	-	-	-	-	-	-	-	-
32.5	-	2	1	-	-	-	-	1	-	1	-	1	-	1	-	-	1	-	1	-	-
33.0	1	2	3	-	-	-	-	3	1	-	-	2	1	-	-	-	-	-	-	-	-
33.5	-	3	-	-	-	1	-	2	2	-	-	-	1	-	-	-	-	-	-	-	-
34.0	-	1	-	-	-	-	-	2	2	-	1	1	1	-	-	-	1	-	-	-	-
34.5	-	3	-	-	-	-	-	3	1	-	1	1	-	-	-	-	-	-	1	-	-
35.0	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.5	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
36.0	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.0	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
37.5	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
39.5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Total	133	419	309	80	225	138	272	500	450	250	388	416	282	251	106	100	700	365	430	275	198

age determination was applied to all data from all localities throughout the period of investigation. Growth data were derived for each year class from 1927 to 1931. Using this information, we determined that the scup of certain ages reach the average modal lengths listed in table 8. Length-weight and age curve for scup is shown in figure 7.

By this length frequency method, it was also possible to determine the approximate composition of the catch in terms of the age of the fish and to compare the relative importance of the broods that composed the catch.

The fishery at Long Branch is representative of the general inshore New Jersey pound net fishery and has, therefore, been used to demonstrate the causes of changes in abundance. In 1928 random samples of unculled pound net catches in that locality revealed the presence of a group with a modal value at about 12.5 cm. in May (fig. 6, table 6). This group increased in length and in relative dominance as the season progressed. By September this group had reached the modal value of about 17 cm. and completely dominated the pound net catch for that month. From previous age analysis it is evident that this dominant group consisted of fish spawned in 1927. In 1928 this brood was too small for market until September, and then only the larger individuals of this class were marketed. Although observations were discontinued in September, it is known from reports by pound net fishermen that these small fish continued to be present in considerable numbers to the end of the season, about November 1.

Table 7.--Length frequencies of scup in random samples from catch by pound nets near Wildwood, N.J., 1929-33[1]

[Numbers of fish]

Length	1929					1930					1931							1932[2]						1933[3]
	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	Oct.	Nov.	May	June	July	Aug.	Sept.	Oct.	May
Cm																								
9.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
9.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.5	7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
11.0	9	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	4	-
11.5	9	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-
12.0	4	-	5	4	-	-	-	-	2	-	-	-	1	1	-	-	-	-	-	8	10	-	-	-
12.5	1	-	1	7	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	7	23	-	-	-
13.0	5	1	4	9	-	-	1	-	1	-	-	-	-	2	-	-	-	-	-	13	39	-	-	-
13.5	2	-	4	20	-	-	1	-	5	-	-	-	-	17	3	-	-	-	-	2	52	10	-	-
14.0	7	1	3	23	-	-	-	-	5	-	-	-	-	19	8	-	-	-	-	3	45	3	-	-
14.5	5	1	3	28	-	-	2	1	14	-	-	-	-	18	11	-	-	-	-	5	69	17	11	-
15.0	12	-	5	35	-	-	2	-	18	1	-	-	-	7	13	-	-	-	-	2	60	14	7	-
15.5	21	3	10	25	2	-	1	1	10	-	-	-	-	5	9	2	-	-	-	2	49	14	33	-
16.0	42	5	35	21	3	-	2	1	8	1	-	-	-	1	2	1	-	-	-	2	32	7	14	-
16.5	67	18	70	27	-	1	2	2	23	1	-	-	-	1	4	1	-	-	-	2	34	7	12	-
17.0	82	17	105	52	3	-	2	2	43	-	-	-	2	-	4	4	-	-	-	6	13	3	31	-
17.5	78	24	92	122	4	4	4	5	52	-	1	-	6	1	4	6	-	-	1	8	2	-	62	-
18.0	74	19	84	168	4	-	1	4	70	2	-	-	20	-	3	11	-	1	2	20	15	3	50	-
18.5	77	20	37	180	22	8	1	2	27	2	2	1	41	7	8	20	-	2	4	40	50	-	39	1
19.0	38	5	24	133	30	7	-	1	13	3	3	3	54	12	26	26	-	3	9	55	52	7	8	2
19.5	30	8	18	68	41	15	2	2	12	13	3	6	81	18	48	37	1	2	7	60	108	19	15	5
20.0	20	1	13	33	52	10	1	5	3	16	5	6	60	35	57	57	2	4	6	37	87	19	-	3
20.5	16	1	10	16	20	27	6	1	3	14	3	3	61	23	72	93	4	2	12	35	32	7	-	7
21.0	19	2	7	10	7	38	9	4	7	10	15	10	49	15	51	116	4	6	11	52	22	20	-	5
21.5	29	-	8	4	2	51	7	8	18	9	38	20	63	19	22	120	15	10	25	72	11	6	-	3
22.0	22	1	5	7	1	67	27	7	41	28	41	17	47	6	9	79	20	28	71	179	24	6	-	1
22.5	23	-	5	5	-	49	27	12	44	22	58	21	34	5	3	27	22	53	106	290	31	14	-	3
23.0	11	-	3	3	-	29	14	5	26	22	49	33	17	1	-	19	7	64	90	251	15	10	-	3
23.5	12	-	3	2	-	14	4	1	20	11	70	45	34	2	-	9	5	64	64	157	6	5	-	3
24.0	15	-	1	2	-	9	1	-	5	3	62	45	19	-	-	3	2	47	64	94	2	4	-	3
24.5	10	-	3	1	-	3	2	-	-	-	59	48	8	4	-	4	3	40	23	52	-	2	-	4
25.0	7	-	3	2	-	4	3	-	2	-	45	31	3	2	-	2	5	49	20	39	-	-	-	4
25.5	6	-	1	2	-	3	1	-	-	-	15	20	1	3	-	-	2	55	26	40	-	-	-	1
26.0	2	-	1	4	-	1	-	-	2	-	11	3	2	4	-	1	1	66	20	16	4	-	-	4
26.5	3	-	2	3	-	-	1	-	1	-	2	5	-	2	-	-	-	62	12	13	-	-	-	6
27.0	4	-	1	3	-	4	1	-	1	-	1	2	-	9	-	-	-	40	12	6	-	-	-	-
27.5	2	-	-	2	-	-	1	-	-	-	2	2	1	3	-	-	-	28	9	4	-	-	-	2
28.0	5	-	1	-	-	-	2	-	-	-	-	1	1	3	-	-	-	21	4	-	-	-	-	2
28.5	4	-	-	4	-	-	-	1	-	-	-	-	-	1	-	-	-	18	2	7	-	-	-	-
29.0	2	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	11	3	6	-	-	-	1
29.5	1	-	-	1	-	-	1	1	1	-	-	-	-	-	-	-	-	11	3	2	-	-	-	-
30.0	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	15	1	4	-	-	-	1
30.5	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	5	3	2	-	-	-	1
31.0	3	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	10	2	-	-	-	-	1
31.5	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	-	-	9	1	3	-	-	-	-
32.0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	9	-	2	-	-	-	-
32.5	3	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	8	1	-	-	-	-	-
33.0	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	2	-	-	-	2
33.5	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-
34.0	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	5	-	2	-	-	-	1
34.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
35.0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-
35.5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-
36.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
37.0	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
38.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
39.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	800	128	575	1,035	191	345	134	66	481	158	486	324	605	246	357	638	93	769	618	1,605	900	197	300	70

[1] Exclusive of catches by pound nets located on Five Fathom Bank.
[2] Individual samples weighted to base of 100 fish.
[3] Observations discontinued in May.

Beginning in 1929 and subsequent years, most of the samples were taken from the catches after small and unmarketable fish had been sorted out and discarded. Consequently, the 1928 year class is not fully represented in the 1929 samples. The May mode of 18 cm. in 1929 is identified as fish in their second year of life and, therefore, of the 1927 brood. This year class comprised most of the catch of the inshore summer pound net fishery at Long Branch in 1929. It was present also at other localities in New Jersey, as shown by observations at Wildwood in the same year (fig. 6, table 7). It is evident that the major increase in yield from the pound nets in 1929 resulted from the successful survival of fish spawned in 1927. The 1927 brood was especially abundant in the inshore pound net fishery in northern New Jersey, but being below legal size or too small for market, the majority were culled out of the catches and discarded. It will be recalled that the catch per trap for these areas (fig. 4) showed a remarkable increase between 1928 and 1929 as a result of the successful spawning and survival of the 1927 brood.

Table 8.--Average modal lengths of scup at beginning and end of summer season during the first 4 years of age.

Year class	Length			
	May - June		Sept. - Oct.	
	Cm.	*Inch*	*Cm.*	*Inch*
0	hatched		9.0	3.5
1	12.0	4.7	16.5	6.5
2	18.5	7.3	20.5	8.1
3	21.5	8.5	22.5	8.8
4	23.5	9.2	24.5	9.6

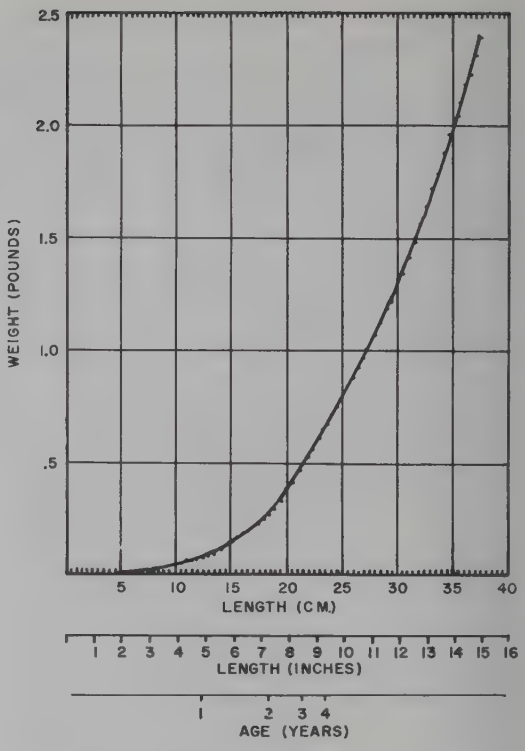


Figure 7.--Length, weight, and age curve for scup.

During the following 3 years (from 1929 to 1932), a series of successful broods contributed to high yields in each year from 1929 to 1935, inclusive, throughout New Jersey. The 1928, 1930, 1931 broods were successful, and only the 1929 year class was relatively poor. Although observations of size and age composition of the catches of the summer fishery terminated with 1932, it is believed that there has been no marked diminution of subsequent annual increments of broods of young fish to the stock, for the yield of the pound net fishery has continued at a high level (fig. 3). This belief is further supported by the presence in the southern winter trawl fishery (fig. 8) of large numbers of fish spawned in the summer of 1932.

The New Jersey pound net fishery for scup depends to a large extent upon the younger and smaller sizes of fish, 2-, 3-, and 4-year olds (7 to 9 inches, approximately) being generally available to the inshore pound nets. This means that any great diminution in the number of the smaller sizes of scup through unsuccessful spawning or other causes would be quickly reflected in the pound net catch within 1 or 2 years following the spawning season of the below-average brood. To maintain the abundance at a high level, there must be a continuous series of years or at least alternate years of successful broods in sufficient abundance to offset a decline resulting from a poor spawning season. Also, a series of successive poor spawning years would be expected to result in extremely poor yields in the pound net fishery in a relatively short time. The low yields prior to 1929 (fig. 4) were no doubt due to unsuccessful spawning just as the high yields after that year were due to successful reproduction in 1927 and subsequent years.

Transition from pound nets to offshore vessels.--The success of the several year classes (1927-31) was also reflected in the catch of the offshore summer vessel fishery (purse seiners and otter trawlers). Although it has not been possible to measure reliably changes in abundance by standard unit of effort based on this fishery, it is known that the vessel fishery has had little difficulty in catching large quantities of scup during the past several summers (1929-35). The proportion of large-sized scup in the samples of available vessel-fishery catches was higher than it was for those from the inshore pound net catches. This suggests that as scup reach the age of about 4 years, they become less available to pound nets in the close inshore

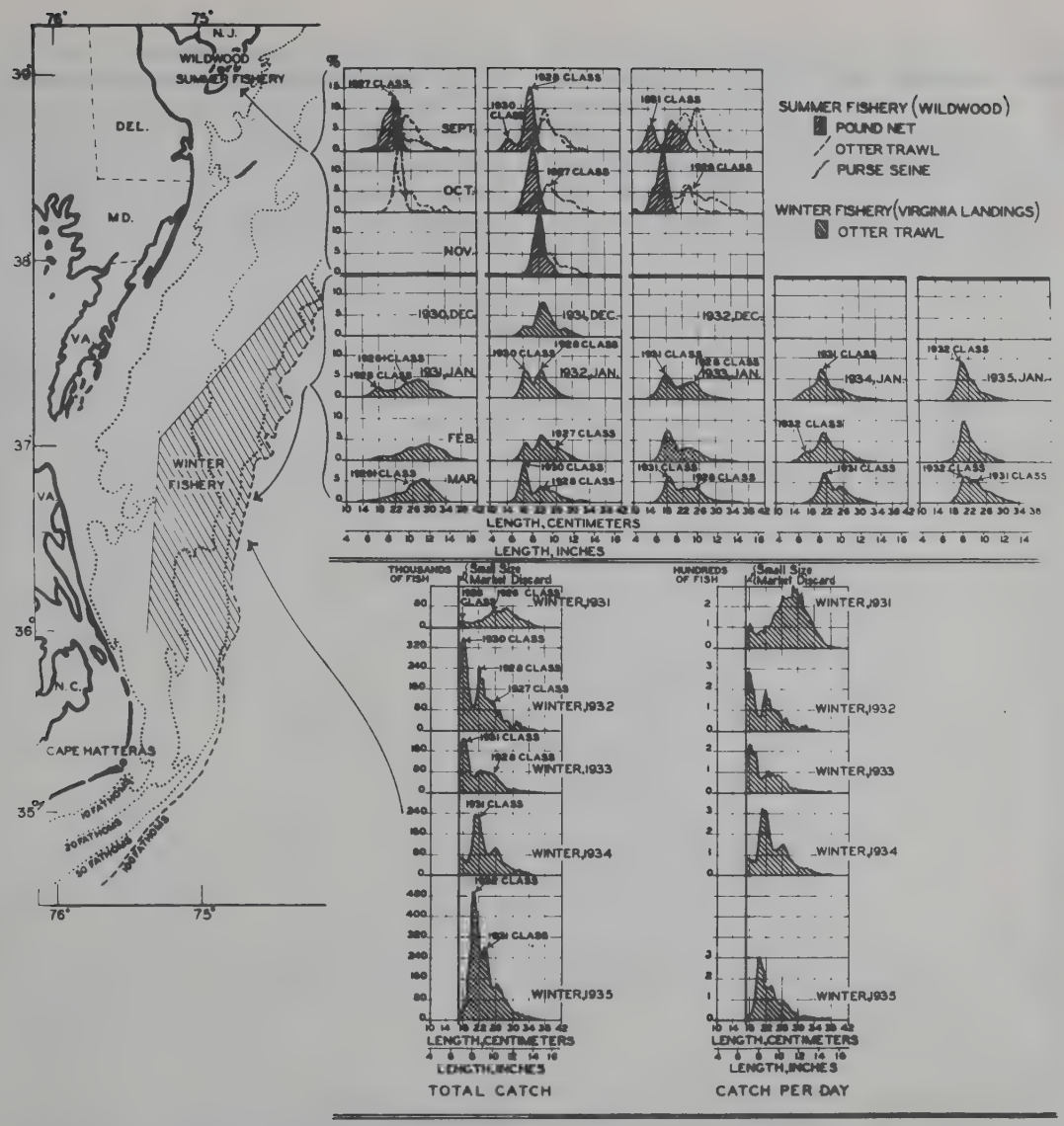


Figure 8.--Comparison of length composition of the autumn catches of scup by the summer fishery and the winter catches by the southern trawl fishery. The curves above the double lines are percentage distributions of sizes obtained by random sampling of the landed catches. The two sets of curves in the lower part of the graph are based on data weighted according to the number of fish landed (total catch) and amount of fishing effort (catch per day).

waters and move offshore to join the concentrations of older and large-sized fish exploited by the vessel fishery (purse seiners and otter trawlers). Evidence of this change is shown in figures 6 and 8 and tables 9 and 10. For example, the 1927 class was available to the New Jersey inshore pound nets from 1928 to 1931. In the latter year, the fish of the 1927 brood, then 4 years old (fig. 6), constituted a large part of the May and June catches there, but from July to the end of the season (November) they moved offshore to areas

fished, at least in part, by the seiners and trawlers (tables 9 and 10). Inshore, from July to November 1931, this brood was replaced by the younger and smaller fish of the 1928 brood. By moving offshore beginning in mid-summer, July 1932, the 1928 brood (then 4-year-old fish) duplicated the movement made the preceding summer by the 1927 brood. With the older and larger individuals of the 1927 brood, they dominated the offshore catches of the vessel fishery. Because observations were discontinued at the end of the 1932 season, it was not possible to trace the movement of broods subsequent to 1928 from inshore to offshore fishing regions, but it may be presumed that they made such movements.

Table 9.--Length frequencies of scup from random sampling of purse seine catches landed at Cape May and Wildwood, N.J., 1929-33

[Numbers of fish]

Length	1929		1930				1931					1932[1]						1933[2]
	July	Sept.	July	Aug.	Sept.	Oct.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	Oct.	May
Cm.																		
10.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
12.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	2	-	-
12.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-
13.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3	24	-	-	-
13.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
14.0	-	-	-	-	-	-	-	-	1	-	-	-	-	-	14	-	-	-
14.5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	10	2	-	-
15.0	-	-	-	-	-	-	2	-	1	-	-	-	-	-	7	-	-	-
15.5	-	-	-	-	-	-	-	-	-	-	-	-	2	-	8	-	-	-
16.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
16.5	-	-	-	-	-	-	2	-	-	-	1	-	-	-	3	-	2	-
17.0	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	1	-
17.5	-	-	-	-	-	-	2	-	3	-	-	-	-	1	4	3	-	-
18.0	1	-	-	-	-	-	-	-	3	-	-	-	2	1	28	-	1	-
18.5	-	-	1	-	5	-	7	-	9	1	-	-	3	4	25	-	3	-
19.0	-	-	2	-	10	-	11	1	15	6	-	-	9	9	27	1	2	-
19.5	-	-	-	2	19	1	4	-	12	14	2	-	10	4	18	4	5	-
20.0	1	-	-	1	15	-	5	-	12	16	1	2	3	-	28	2	2	-
20.5	1	-	-	-	15	1	12	-	6	18	4	1	3	6	6	6	3	-
21.0	1	1	6	1	13	4	18	-	8	18	6	1	8	9	9	14	9	-
21.5	-	-	14	4	35	4	28	-	8	23	7	-	12	21	20	5	6	-
22.0	1	-	17	11	66	5	22	2	6	27	4	4	42	31	55	7	7	-
22.5	4	-	12	11	150	14	31	-	4	18	10	12	65	62	74	8	11	-
23.0	-	-	14	10	156	23	19	4	5	50	12	14	77	97	124	24	22	-
23.5	6	1	10	15	124	32	23	1	4	39	23	7	68	83	114	23	34	-
24.0	11	2	2	5	64	21	22	4	4	38	27	12	43	69	98	36	45	-
24.5	10	2	1	2	26	7	11	1	1	21	26	11	43	71	100	41	20	-
25.0	10	3	2	3	20	1	8	12	3	22	12	11	31	71	111	49	26	1
25.5	13	-	5	6	26	1	7	1	-	9	8	12	39	98	114	67	25	3
26.0	11	6	5	7	28	-	10	6	-	4	13	19	45	113	93	84	23	-
26.5	23	7	4	8	29	1	10	5	-	3	9	18	40	65	70	79	13	-
27.0	30	5	8	2	26	-	7	8	1	3	10	10	40	63	40	65	31	-
27.5	32	10	6	8	21	-	10	16	-	6	5	14	26	31	51	40	18	1
28.0	50	11	3	9	28	-	9	12	-	2	8	7	8	41	36	34	10	4
28.5	42	10	8	14	19	1	14	12	1	1	7	8	12	58	40	40	14	4
29.0	38	14	5	11	23	-	5	12	1	1	12	14	17	47	45	15	23	8
29.5	26	2	9	10	21	1	10	19	2	-	2	15	18	42	43	20	21	7
30.0	31	9	7	10	14	-	7	23	-	-	4	15	13	40	44	12	13	5
30.5	32	7	6	7	9	-	6	11	-	-	2	13	15	43	40	9	22	11
31.0	31	5	10	12	13	-	2	11	-	-	3	16	6	38	26	4	15	13
31.5	21	9	3	5	13	-	11	18	-	-	-	9	19	35	28	4	15	7
32.0	17	6	4	4	7	-	6	14	-	-	2	10	20	24	16	-	14	13
32.5	10	4	4	5	4	-	7	8	-	-	1	9	5	21	20	-	11	7
33.0	9	1	-	5	-	-	1	10	-	-	2	7	13	19	17	-	12	9
33.5	5	1	-	1	1	-	-	8	-	-	1	3	10	16	10	-	7	1
34.0	8	1	-	2	1	-	-	6	-	-	-	4	13	15	4	-	4	1
34.5	6	-	-	1	1	-	-	2	-	-	-	6	8	9	7	-	3	1
35.0	2	-	1	1	-	-	-	6	-	-	1	7	3	7	2	-	3	-
35.5	-	-	-	1	2	-	1	4	-	-	-	3	2	5	4	-	1	1
36.0	1	-	-	-	-	-	2	4	-	-	-	3	2	6	3	-	-	-
36.5	-	1	1	-	-	-	-	5	-	-	-	-	-	3	1	-	1	1
37.0	1	-	1	-	1	-	1	1	-	-	-	2	-	5	1	-	2	-
37.5	-	-	-	-	1	-	-	1	-	-	-	2	-	2	1	-	-	-
38.0	-	-	-	-	-	-	-	1	-	-	-	-	2	1	-	-	-	-
38.5	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
39.0	1	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
39.5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
41.0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	488	118	172	194	1,006	117	355	250	110	340	225	301	798	1,392	1,694	700	500	98

[1] Individual samples weighted to base of 100 fish.
[2] Observations discontinued in May.

Table 10.--Length frequencies of scup from random sampling of otter trawlers landing at Cape May and Wildwood, N.J., 1929-33

[Numbers of fish]

Length	1929					1930				1931[1]							1932[1]						1933[2]
	May	June	July	Sept.	Oct.	May	July	Sept.	Oct.	May	June	July	Aug.	Sept.	Oct.	Nov.	May	June	July	Aug.	Sept.	Oct.	May
Cm.																							
13.5	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.0	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-
15.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	2	-
16.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-
16.5	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	12	-
17.0	4	-	-	-	1	-	-	-	-	3	-	1	-	-	-	-	-	-	-	-	3	13	-
17.5	5	-	2	1	-	-	-	-	-	2	-	-	-	-	-	-	1	1	-	-	-	20	-
18.0	7	-	1	-	1	-	-	-	-	9	-	-	-	-	-	1	5	2	-	-	2	26	-
18.5	8	-	1	1	-	-	-	-	-	28	-	-	-	2	-	1	9	2	-	-	3	37	-
19.0	4	1	1	2	3	-	-	-	-	37	1	3	1	2	1	1	16	2	-	-	6	36	-
19.5	4	-	2	4	1	-	-	-	-	47	3	3	3	13	2	-	19	1	2	-	6	21	-
20.0	8	-	1	2	10	-	-	1	-	41	5	3	11	19	4	1	21	-	2	-	15	13	-
20.5	4	4	5	3	11	-	-	-	1	60	4	8	11	21	12	-	17	3	2	-	40	19	-
21.0	4	4	4	1	22	-	-	-	1	71	14	8	18	43	16	23	23	2	2	-	51	19	-
21.5	10	-	8	-	17	-	-	-	2	87	13	10	28	24	31	36	51	14	6	-	40	16	1
22.0	9	6	2	1	15	-	1	-	4	71	12	19	49	32	30	24	104	27	11	1	49	20	5
22.5	17	5	4	1	7	1	2	3	10	67	17	21	53	35	23	18	110	32	35	3	50	22	16
23.0	27	7	4	-	5	1	2	6	8	90	36	35	101	52	21	18	115	73	39	3	67	23	22
23.5	32	12	13	4	6	-	3	-	3	111	59	55	113	62	38	6	114	65	24	9	88	54	42
24.0	29	19	12	3	8	1	2	1	3	122	39	50	117	46	60	10	115	75	48	12	44	29	29
24.5	25	12	14	5	4	-	4	7	2	79	40	33	92	77	71	17	92	75	31	16	42	35	20
25.0	26	12	14	6	14	2	-	6	3	58	47	35	83	40	71	15	95	102	39	16	51	17	31
25.5	19	10	12	4	10	1	5	3	3	29	36	23	82	26	57	12	99	99	40	16	41	15	25
26.0	22	6	12	6	6	3	2	5	4	25	46	35	81	39	62	10	105	74	32	4	29	11	14
26.5	23	19	14	8	5	4	2	4	2	25	31	33	75	28	35	3	89	94	44	7	26	12	8
27.0	21	19	22	5	2	5	4	4	5	24	30	33	69	27	44	7	56	46	21	1	12	6	12
27.5	35	12	15	7	3	1	4	3	2	22	38	46	60	32	39	2	49	62	18	1	4	1	15
28.0	28	24	10	9	-	4	3	4	-	28	27	31	60	15	24	9	42	62	9	4	8	3	12
28.5	33	13	20	7	3	4	6	-	1	25	26	38	53	15	30	4	60	57	17	-	7	3	4
29.0	23	15	16	2	1	3	3	3	2	22	37	31	64	12	31	6	39	53	15	1	1	1	8
29.5	16	11	15	4	1	6	4	-	1	25	26	27	44	11	27	5	33	56	9	-	1	3	7
30.0	15	5	8	5	2	3	4	2	-	17	38	23	40	7	23	4	40	45	11	-	-	1	1
30.5	15	13	6	2	2	2	2	1	2	15	31	22	43	7	39	5	56	46	7	1	-	1	-
31.0	11	8	2	-	-	1	1	-	2	21	13	20	28	10	24	4	39	40	10	-	-	1	7
31.5	5	3	1	1	-	1	-	1	-	13	18	13	25	2	23	4	33	30	10	-	1	3	1
32.0	-	5	4	2	-	2	1	-	-	6	3	10	15	5	10	2	27	29	6	1	1	-	2
32.5	4	7	-	-	-	2	-	-	-	10	9	7	9	1	13	-	18	20	5	1	-	-	4
33.0	5	3	-	1	-	-	-	-	-	2	7	6	4	-	5	2	35	30	4	-	2	-	5
33.5	6	5	2	-	-	1	1	-	-	2	2	3	2	4	11	-	14	11	4	-	-	-	1
34.0	2	2	-	-	-	-	-	-	1	5	2	2	3	-	9	-	17	17	2	-	-	-	-
34.5	2	2	-	-	-	-	-	2	2	2	3	3	2	1	8	2	7	13	1	-	-	-	1
35.0	2	4	1	-	-	-	-	-	1	4	2	1	4	-	3	-	10	6	-	-	-	-	1
35.5	3	2	-	-	-	-	-	-	-	-	1	1	2	-	6	-	5	2	2	-	2	-	-
36.0	2	-	-	-	-	-	-	-	-	3	-	1	-	-	-	-	2	17	-	-	-	-	-
36.5	1	1	-	-	-	-	-	-	-	-	2	1	-	-	2	-	3	5	-	-	-	-	-
37.0	-	1	-	-	-	-	-	-	-	2	2	2	-	-	-	-	2	3	-	-	-	-	-
37.5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	2
38.0	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	2	-	-	-	-	-
38.5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
39.0	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-	1
39.5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-
40.0	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
41.0	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
Total	518	273	248	98	160	48	56	56	65	1,313	720	701	1,446	710	905	252	1,796	1,401	510	97	692	503	297

[1] Individual samples weighted to base of 100 fish.
[2] Observations discontinued in May

The dearth of smaller and younger scup in the offshore region cannot be explained by culling, because there was no such practice on the seine boats during the years studied. Moreover, in 1928, 1929, and 1930, when prices were high, 2- to 4-year-old fish would have been marketed had they been present in the offshore catches. It appears, therefore, that there is an inshore to offshore migration of the older fish. In 1931 and subsequent years, when markets were glutted and prices depressed, numerous reports were received of the seiners fishing offshore either trying to avoid setting around large schools of good, market-sized scup (mostly 4 years and older) or when they did set, often permitting most or all of the school to escape.

This offshore movement with advancing age suggests that the summer scup population along the southern New Jersey coast may be divided roughly into two main parts: (1) An inshore group, consisting generally of smaller and younger fish (2 to 4 years old, 7 to 9.5 inches long, and weighing one-quarter to five-eighths of a pound) and constituting the bulk of the pound net catch; and (2) an offshore group, consisting generally of larger and older fish (4 to 7 years old, approximately 9.5 to 12 inches long, and weighing 5/8 to 1-1/4 pounds)

and comprising the bulk of the catch by seiners and, to a somewhat lesser extent, that of trawlers.

Statistics of the Fishery, New York-Southern New England

Changes in total yield.--The gross yield of scup in New York is smaller than in New Jersey, but, as in the latter place, the pound nets have contributed a large part to the total yield throughout most of the history of the fishery (fig. 3, table 11). During the period of expansion, from 1890 to 1901, the scup fishery was dominated by pound nets. From 1904 to 1933, however, the catch of pound nets became relatively less important, as haul seines contributed a large share between 1901 and 1908, and purse seines and otter trawls contributed considerable part of the total yield beginning in 1921. Although sharp changes occurred in the relative importance of the catch by different types of gear, the total catch itself remained at almost the same level from 1904 to 1933. No definite explanation can be given for the causes of the changes in the catch of different gear. The use of purse seines for scup began in 1920, and this gear may have been readily adopted by New York fishermen at that time. In recent years, otter trawls have become a most efficient gear for scup through the adoption of the balloon net that has been developed since 1930 by the winter trawl fishery. It is interesting to note that the New York yield of scup did not undergo the sharp fluctuations that occurred in New Jersey (fig. 3).

Two impressive features concerning the yield of scup in Rhode Island are: (1) An

Table 11.--Catch of scup landed in New York by different types of gear from 1889 to 1933[1]

[In pounds]

Years	Pound nets[2]	Seines		Otter trawls	Hand-lines	Gill nets	Fyke nets	Total
		Haul	Purse					
1889[3]	-	-	-	-	-	-	-	348,316
1890	330,125	-	-	-	-	-	38,718	368,843
1891	310,358	-	-	-	-	-	40,500	350,858
1897	676,290	52,750	-	-	3,233	7,100	7,600	746,973
1898	536,532	45,260	-	-	49,305	4,300	10,000	645,397
1901	515,894	[4] 203,705	-	-	80,330	4,660	-	804,589
1904	597,880	[4] 858,550	-	-	36,598	800	-	1,493,828
1908	52,000	[4] 1,235,000	-	-	6,200	200	-	1,293,400
1915[5]	423,860	-	-	-	-	-	-	1,026,736
1917[5]	242,962	-	-	-	-	-	-	1,212,650
1921	267,455	500	1,006,400	-	22,870	150	-	1,297,375
1926	385,421	1,600	485,482	-	52,215	2,775	-	927,493
1929	506,714	-	500,000	[6] 187,700	27,200	900	-	1,222,514
1930	551,746	-	500,000	[6] 151,025	15,400	150	-	1,218,321
1931	666,633	-	414,800	[6] 237,234	18,315	-	-	1,336,982
1932	501,252	1,225	383,700	[6] 155,810	31,786	-	[7] 390	1,074,163
1933	1,020,187	600	-	[6] 432,766	24,600	-	-	1,478,153

[1] U.S. Bureau of Fisheries (U.S. Commission of Fish and Fisheries) statistical canvasses with the exception of 1908 when canvass was made by the U.S. Bureau of the Census.
[2] Includes floating traps.
[3] Catch by gear not available.
[4] Possibly includes some catch by purse seines.
[5] Catch by gear other than pound nets not available.
[6] Includes catch by New York vessels engaged in winter trawl fishing off the Virginia Capes.
[7] By scap nets.

apparent sharp decline in gross yield between 1919 and 1924 was followed by a continued low level of catch to 1933 and (2) practically the entire catch since 1919, and probably before, has been made by floating traps (fig. 3, table 12). In the canvass years, from 1889 to 1919, the average annual catch for Rhode Island was 6 million pounds. This exceeded the annual catch of either New York or New Jersey for the same period. Since 1919, however, the annual yield has averaged 1.5 million pounds, which is considerably below the New Jersey catch but somewhat higher than the New York catch for the same period. This significant change in yield between 1919 and 1924 could have resulted from a reduced amount of gear or a decrease in abundance or availability of the fish or both. Although complete statistics are not available, private records of trap operators and files of the Rhode Island Division of Fish and Game indicate that between 1919 and 1924 the number of floating traps decreased approximately 40 percent and by 1933 had declined an additional 35 percent. Leading producers attributed the decline in traps, especially after 1924, largely to the inability of fishermen to dispose of their catch at profitable prices rather than to any decreased supply of fish. This opinion is supported by the fact that there was no interruption in the practice of "pounding" scup or complaints from the industry of scarcity of fish during the period 1919-24. It does not follow, however, that the decline in catch was due entirely to a decline in fishing effort. For instance, even though the number of traps declined 40 percent between 1919 and 1924, the total yield decreased approximately 86 percent. The decline in number of traps, therefore, cannot be explained altogether by a diminished market but must have been due in part to an actual decline in abundance or availability of scup. Since no biological observations on the catch were made from 1919 to 1924, it is not possible to say just how much this decline may have been due to a natural decrease in the supply of fish.

The record of scup landings in Massachusetts is also based on results of statistical canvasses by the U.S. Bureau of Fisheries during the period 1879-1933 inclusive (fig. 3,

Table 12.--Catch of scup landed in Rhode Island by different types of gear from 1880 to 1933[1]

[In pounds]

Years	Pound nets	Floating traps	Haul seine	Otter trawls	Gill nets	Fyke nets	Total
1880[2]	-	-	-	-	-	-	6,691,000
1887	[3] 3,027,200	-	-	-	2,833	-	3,030,033
1888	[3] 4,206,000	-	-	-	1,700	-	4,207,700
1889[2]	-	-	-	-	-	-	6,064,000
1898	[3] 6,387,925	-	-	-	-	2,300	6,390,225
1902	[3] 6,828,390	-	3,500	-	-	1,400	6,833,290
1905[2]	-	-	-	-	-	-	5,540,000
1908	[3] 4,616,000	-	-	-	-	-	4,616,000
1919	575,640	7,685,500	-	-	-	-	8,261,140
1924	447,625	744,000	-	-	-	-	1,191,625
1928	66,510	1,936,856	-	-	-	-	2,003,366
1929	12,625	1,611,604	-	-	-	-	1,624,229
1930	253,840	1,371,750	-	20,000	-	-	1,645,590
1931	11,400	1,166,000	-	-	-	-	1,177,400
1932	8,500	1,957,919	-	-	-	-	1,966,419
1933	123,578	1,878,853	-	17,000	-	-	2,019,431

[1] U. S. Bureau of Fisheries (U.S. Commission of Fish and Fisheries) canvasses with the exception of 1908 when made by the U.S. Bureau of the Census.
[2] Catch by gear not available.
[3] Includes catch by floating traps, wiers.

table 13). In volume, Massachusetts landings are comparable to those of New York but are less than those of Rhode Island or New Jersey. In the earlier years (1879-1908), pound nets caught most of the scup; but in recent years (1929-33), otter trawls and handlines have become increasingly important and have been largely responsible for the remarkable increase in total yield. Most of the catch by otter trawls was in the winter, off the Virginia Capes (fig. 2), and provided no information on the changes in the local summer scup fishery.

Although the accuracy and completeness of records of the pound net catch are subject to the same influencing factors as in other States, the fluctuations in the yield of this gear appear to reflect changes in the total scup catch in Massachusetts. In addition to the Bureau's canvass records, statistics on the Massachusetts catch of pound nets are available from annual reports of the State's Commission of Fisheries and Game. These have been presented by Bigelow and Welsh (1925). They show a tremendous and rapid decline in the catch from 3.6 million pounds in 1896 to 200,000 pounds in 1902 followed by continued low levels until 1921. This decline may not be quite as drastic as these data indicate, because the records are subject to much inaccuracy. In 1901 when low catches were reported, it is a matter of record that it was difficult to impress operators with the importance of submitting accounts accurately and regularly, in spite of a newly introduced system of collecting statistics. Since this system was an improvement over the one previously in use, there is considerable doubt as to the validity of the catch statistics from 1896 to 1902 depicted by Massachusetts State records. From other records, particularly the private logs of certain operators, it appears that the total yield of pound nets in Massachusetts waters has decreased considerably during the past 20 years. This decrease resulted mainly

Table 13.--Catch of scup landed in Massachusetts by different types of gear from 1879 to 1933[1]

[In pounds]

Years	Pound nets[2]	Haul seines	Otter trawls	Hand-lines	Gill nets	Totals
1879[3]	-	-	-	-	-	1,022,000
1887[4]	1,703,092	-	-	-	-	2,322,331
1888[4]	1,076,896	-	-	-	-	1,785,839
1889[3]	-	-	-	-	-	2,501,000
1898	957,225	1,000	-	85,400	-	1,043,625
1902	476,200	-	-	112,700	-	588,900
1905[3]	-	-	-	-	-	1,019,000
1908	793,000	[5] 800	-	329,000	13,000	1,135,800
1919	74,714	-	1,000	2,910	-	78,624
1924	115,346	-	200	41,775	1,000	158,321
1928[3]	71,066	-	66	784,140	-	855,272
1929	85,413	-		822,415	-	907,828
1930	176,897	-	[6] 145,741	469,370	-	792,008
1931	97,332	-	[6] 1,334,535	521,000	-	1,952,867
1932	104,742	-	[6] 2,057,274	264,500	-	2,426,516
1933	118,932	-	[6] 1,788,178	226,300	-	2,133,410

[1] U. S. Bureau of Fisheries (U. S. Commission of Fish and Fisheries) statistical canvasses with the exception of 1908 when canvass was made by the U. S. Bureau of the Census.

[2] Includes catch by floating traps, weirs.

[3] Catch by gear not available.

[4] Catch by gear other than pound nets not available.

[5] Includes otter trawls.

[6] Includes catch by Massachusetts vessels engaged in winter trawl fishing off the Virginia Capes.

from a decline, from 1928 to 1933, in the number of nets operated, probably because of increased fishing at other points along the coast, greater market competition, and the discarding, during 1929-35, of large quantities of fish that in previous years would have been marketable.

Measurement of fluctuations.--To measure the magnitude of changes in abundance, in the region from New York to New England, the catch per trap was computed from private records of operators in the vicinity of Fire Island and Montauk, N.Y., Newport, R.I., and Woods Hole, Mass.

At Fire Island, the catch per trap was low between 1925 and 1930, rising in 1931, and subsequently reaching a peak in 1933 (fig. 4). The decline in 1934 and 1935 might well have been the result of discarding fish because of prevailing poor market conditions.

At Montauk, at the eastern tip of Long Island, the catch of scup is relatively small compared to the rest of the coast, and hence the fluctuations are not considered significant in the statistical analysis of the catch.

At Newport, the trend of catch has been similar to that of the ocean traps off Fire Island. Large catches were made in both places from 1931 to 1935 inclusive. The picture of fluctuations in catch per trap at Newport is, however, not the true picture of actual catches. Because of the practice of "pounding", a difference exists between the reported landings and the actual catches at sea.

"Pounding" consists of putting a large pound or square bag at the head of each trap and slowly running the trapped scup over the cork lines into it when the net is hauled. These pounds have a capacity of 400 to 500 barrels (approximately 200 pounds of live fish per barrel) and, when filled, are towed to some sheltered cove or inlet along the nearby shore and anchored. Hundreds of barrels of scup can be pounded each year. When the main scup runs have passed and the market recovers to fair prices, shipments are made from these pounds throughout the summer when the commercial fishery for the region is not in operation at that part of the coast. Since 1930, however, there has undoubtedly been less profit from this practice because the larger catches of scup along the New Jersey coast throughout the summer have competed seriously with pounded scup caught in Rhode Island.

Pounding results in reported catches being more a record of shipments than of amounts actually caught. No complete records are available of the amounts pounded. In addition, the lack of sufficiently reliable data on the changes in amount of gear makes it practically impossible to obtain any accurate measure of changes in abundance or in availability on a catch per trap basis. However, since the trend of the Newport catches follows, in general, that of the Fire Island catches where pounding is not practiced and a fairly accurate record of the change in gear is available, it is probable that the catch of the Newport traps indicates, in a general way, the trend of the major fluctuations in the stock present at that part of the coast.

At Woods Hole, the northern end of the range and comparatively near to Newport, the trend, as indicated by the catch per trap, is markedly different from that of either Newport or Fire Island or points along the New Jersey coast. In recent years the trend of the catch per trap has been downward, while at most other localities along the coast, it has been upward (fig. 4).

Causes of changes in yield.--To determine whether changes in the catch per trap data in New York and southern New England areas are due to changes in availability or to changes in abundance, it is necessary to consider carefully the habits of the scup along this particular part of the coast. As previously stated, scup occur in the general region from Fire Island to Woods Hole in the greatest commercial quantities during 8 to 10 weeks in the spring (end of April to end of June), when large schools of spawning fish make their appearance in the close inshore waters, particularly along the Rhode Island coast. During this period, the trap catches are large, but after the main spawning season, the catches decline sharply until the fishermen

cannot profitably operate these gear solely for scup. The question is "Where do these fish go?"

In experiments at Woods Hole, scup were tagged and released in early summer (June). Those recaptured later in the summer, aside from the few taken locally and immediately following tagging, were widely scattered in all directions from Woods Hole--as far east as Muskegat Channel and Nantucket Sound and as far west as Montauk. Some recaptures were also made nearer Woods Hole, along both shores of Buzzards Bay, Mass. Furthermore, otter trawlers operating off Fire Island have reported (1936) good catches of scup offshore (15 to 20 miles) in depths of 20 fathoms or less. This evidence suggests that after spawning scup move offshore and scatter widely.

Marked changes in the catch at certain points also result from significant changes in the size of fish composing the schools that appear each spring. Throughout the New York-southern New England area, the scup season is more or less continuous without any apparent segregation into sizes of fish. At Newport, however, three distinct runs of scup have frequently been observed in a season. The first run appears about the last of April or the first of May and continues to about May 10; it consists usually of larger fish (1-1/2 to 2-1/2 pounds) than in the subsequent runs. The second run, consisting mainly of medium-sized scup (3/4 to 1 pound), continues until about May 20. The third run, consisting of small-sized fish (about 7 to 8 inches long and weighing one-quarter to one-half pound), remains through to the middle or the end of June. This separation of the spring runs into three more or less distinct size groups has been characteristic of the fishery along the Rhode Island shore since early times.

Recently (1930), trap operators reported that the three runs of fish have been less distinctly separated into size groups than in former years. Some Rhode Island operators blame this condition on the activity of the otter trawlers operating in the winter off the Virginia Capes, charging that the schools are broken up and widely distributed in their winter habitat. Others believe that the unusual water temperature conditions may be the cause. The latter appears the more probable explanation, since the mixing of the runs is not unusual or characteristic of only present day fishing. Lyman (1872) in describing the approach of scup to the southern New England coast states:

> The army of scup advancing to its spawning grounds in May . . . is in two or three divisions of which the first is usually the most numerous and contains the oldest fish; there follows the second, and then the third, which is usually fewer in numbers and of smaller individuals. Sometimes, and in some places, the great and the smaller scup come mixed together, and the "runs" are not well defined.

Frequently in June there is a run of small fish of unmarketable size, 10 to 12.5 cm. (4 to 5 inches) from the previous summer's spawning which, if numerous, are usually sifted from the catch by means of a large-mesh apron attached to the pocket.

The height of the trapping season is about May 10 to 15 when fish of large and medium sizes are running. It is not possible to state the numerical strength of these runs because (1) most trap operators do not keep records of the amounts actually caught and (2) the quantity of discarded fish varies from year to year and cannot be reliably estimated. In most years, however, the first and second runs compose the bulk of the actual catch. The fish of the last run appear to be more abundant than those of the first two, but being on the whole smaller, many of them are discarded as unsalable. Hence, the third run contributes only a relatively small percentage of the reported catch. Especially has this been true in recent years when the amount of fish caught has far exceeded the demand and only the larger sizes have been landed, marketed, and reported in the records.

At Newport, considerable care was taken to obtain unselected samples of the catch for age-length analysis because of the practice of pounding. Measurements were obtained only from those traps on days in which pounding was not done, or through bushel lots of un-

sorted fish brought in through the kindness of the trap boat captains.

This characteristic, changing composition of the catches at Newport and Fire Island is shown in figure 6 and tables 14 and 15. Figure 6 allows comparison with New Jersey catches as to age and size of fish. Choosing the 1927 class for comparing the effects on the catch of successful reproduction by several consecutive broods, we find that if effected sudden record high catches in the New Jersey fishery beginning in 1929; and, although it did appear at Newport and Fire Island in 1929, it accounted for a smaller proportion of the catch and did not become dominant there until 1930. Similarly, the 1928 class, which contributed greatly to the New Jersey pound catch for the first time in 1930, did not attain dominance at Newport and Fire Island until 1931.

These differences in fluctuations of the New Jersey fishery compared with that of New York-southern New England may be explained in part (1) by differences in the age and size composition of the catches and (2) by fishing practices affecting the reported amounts caught. For instance, both fisheries show upward trends in catch per trap in recent years of about the same percentage increase, but differ in magnitude and in individual years (fig. 4). This might be explained on the basis that the catch of a fishery depending on the

Table 14.--Length frequencies of scup in random samples from the catch by floating traps near Newport, R.I., 1930-31

[Number of fish]

Length	1930			1931		Length	1930			1931	
	April	May	June	May	June		April	May	June	May	June
Cm.						Cm.					
11.0	-	-	-	-	22	27.5	10	119	3	84	28
11.5	-	-	-	-	32	28.0	12	119	2	79	24
12.0	-	-	-	-	54	28.5	11	97	2	72	35
12.5	-	-	-	-	55	29.0	11	115	1	90	18
13.0	-	-	-	-	59	29.5	21	141	2	81	22
13.5	-	-	-	-	68	30.0	19	136	2	102	18
14.0	-	-	-	-	35	30.5	27	162	2	122	15
14.5	-	-	-	-	11	31.0	26	127	-	137	10
15.0	-	1	-	-	4	31.5	26	118	-	142	16
15.5	-	5	-	-	-	32.0	19	99	1	123	17
16.0	-	11	-	-	-	32.5	18	88	-	120	11
16.5	-	20	-	-	10	33.0	12	73	-	116	4
17.0	-	50	-	3	30	33.5	10	64	-	74	2
17.5	-	67	-	3	48	34.0	6	49	-	83	5
18.0	1	71	2	9	86	34.5	11	28	-	57	1
18.5	1	98	-	7	103	35.0	12	26	-	44	1
19.0	1	111	-	13	139	35.5	7	16	-	29	2
19.5	1	88	5	17	145	36.0	7	7	-	17	1
20.0	-	75	3	16	95	36.5	7	12	-	14	1
20.5	-	69	7	23	66	37.0	1	9	-	20	-
21.0	-	81	6	19	73	37.5	3	6	-	8	1
21.5	3	149	13	32	147	38.0	1	6	-	5	-
22.0	6	205	29	68	201	38.5	1	4	-	2	-
22.5	9	257	33	89	244	39.0	1	1	-	5	-
23.0	5	258	31	99	193	39.5	1	1	-	5	-
23.5	11	191	25	73	168	40.0	1	-	-	2	-
24.0	11	199	9	59	104	40.5	-	-	-	1	-
24.5	12	137	5	89	99	41.0	-	1	-	-	-
25.0	6	120	8	85	103	43.0	-	-	-	1	-
25.5	13	141	4	84	78	45.0	1	-	-	-	-
26.0	15	141	3	90	49						
26.5	12	135	5	67	40	Total	402	4,454	207	2,682	2,827
27.0	13	150	4	92	34						

TABLE 15.--Length frequencies of scup in random samples from the catch by pound nets near Fire Island, N. Y. 1928-31

[Numbers of fish]

Length	1928	1929			1930			1931		
	May	May	June	July	May	June	July	May	June	Sept.
Cm.										
10.5	-	-	-	-	-	-	-	-	6	-
11.0	-	-	2	-	-	-	-	-	8	-
11.5	-	1	4	-	-	-	-	-	19	-
12.0	-	1	-	-	-	-	-	-	9	-
12.5	-	-	1	-	1	-	-	-	9	-
13.0	-	-	-	-	1	-	-	-	8	-
13.5	-	-	-	-	2	1	-	-	1	-
14.0	-	-	-	-	1	-	1	-	1	-
14.5	-	-	-	-	2	-	-	-	1	-
15.0	-	-	2	-	2	-	-	-	2	-
15.5	-	2	9	-	-	4	-	-	-	-
16.0	-	9	15	-	8	7	-	1	2	-
16.5	-	17	23	-	19	10	-	-	6	-
17.0	1	21	17	-	33	19	2	1	11	-
17.5	2	16	18	-	38	9	4	5	9	-
18.0	5	32	11	-	35	17	5	5	15	-
18.5	6	31	3	3	30	13	9	8	24	-
19.0	6	42	1	6	31	12	13	8	12	-
19.5	5	41	7	4	26	13	10	6	11	-
20.0	5	26	4	17	16	17	5	7	7	3
20.5	7	23	4	9	13	7	3	3	4	7
21.0	10	23	10	7	12	11	6	9	6	6
21.5	26	18	2	5	18	16	9	8	7	7
22.0	29	16	1	5	33	19	8	9	18	2
22.5	27	30	4	6	33	16	13	20	9	3
23.0	20	31	9	6	34	17	6	15	5	-
23.5	10	14	7	7	31	14	9	8	7	3
24.0	9	23	10	15	12	3	10	10	12	8
24.5	6	22	5	7	17	2	6	17	3	2
25.0	4	34	14	11	14	4	3	11	2	2
25.5	10	26	7	11	6	3	1	14	6	2
26.0	12	16	6	11	11	3	3	7	3	3
26.5	13	15	4	12	17	2	1	8	5	-
27.0	11	10	4	4	7	3	3	11	4	-
27.5	14	18	-	4	6	3	-	10	3	-
28.0	16	17	3	8	13	1	2	13	6	1
28.5	17	20	4	8	9	-	1	16	3	-
29.0	15	19	5	12	8	3	-	17	3	-
29.5	5	21	5	16	11	-	2	16	1	-
30.0	4	18	4	6	5	2	4	13	4	-
30.5	2	17	2	10	12	-	3	15	6	-
31.0	9	12	4	4	6	-	-	20	3	-
31.5	4	10	-	13	7	-	2	15	5	-
32.0	6	12	1	6	2	1	-	14	3	-
32.5	2	5	1	8	4	-	-	11	4	-
33.0	2	6	-	2	5	-	-	20	-	-
33.5	2	6	-	5	4	-	-	15	2	-
34.0	3	4	1	3	-	-	-	10	-	-
34.5	3	-	-	2	3	-	1	5	1	-
35.0	2	3	-	1	1	1	-	7	3	-
35.5	1	2	2	3	1	-	1	6	-	-
36.0	-	4	-	3	1	-	-	4	-	-
36.5	2	1	-	-	-	-	-	1	-	-
37.0	2	-	-	-	-	-	-	-	-	-
37.5	-	1	2	-	2	-	1	2	-	-
38.0	1	2	-	-	1	-	-	-	-	-
38.5	-	-	-	-	1	-	-	2	-	-
39.0	-	1	-	1	1	-	-	-	-	-
39.5	-	-	-	-	1	-	-	-	1	-
40.0	-	1	-	-	-	-	-	1	-	-
42.0	-	-	-	-	-	-	-	-	1	-
Total	336	740	238	261	607	253	147	424	301	49

younger fish, mainly 2 and 3 years of age, should show sharper fluctuations than one depending on several age groups of older fish. Since each brood of young scup is separated by size differences, changes in the amount of each brood by varying success of reproduction is quickly reflected in the catch that depends mainly only on one or two young age groups. Such is the case in New Jersey. On the other hand, in the case of a fishery depending on older and larger fish (New York to southern New England), the broods are less distinctly separated from each other by size difference, and the annual increments are relatively less than in the case of younger broods because of the mortality from long exploitation and natural causes. Hence, the catch remains more nearly constant and reflects changes only when they attain major importance. Therefore, although the pound net and trap fisheries of New York and Rhode Island experienced an increase in yield simultaneously with that of New Jersey because of the entrance of large broods of young scup, these younger fish were less conspicuous in the presence of larger and older fish in greater numbers.

It can also be seen that the catch per trap in the fishery in southern New Jersey did not fluctuate in the same manner as that in northern New Jersey (fig. 4). This would indicate that the fisheries of the two areas catch different populations of scup. This situation is not clear since samples of scup in the two areas show that broods of the same year appeared in both areas. It is possible that the same broods are found in both areas but in different abundance.

Moreover, the practices of pounding scup and sifting out small fish tend to diminish the apparent importance of the younger fish in the catch and to reduce the amount of reported catch. The extent of this practice from year to year, depending on the runs of fish and economic conditions, naturally affects fluctuations based on the catch records. This also may explain why certain broods of younger and smaller fish, which comprised the bulk of the catch of New Jersey pound net fishery in certain recent years, were relatively less reliable measures of fluctuation than the catch of the New York-Rhode Island fishery in the same seasons.

From this discussion it is suggested that, although the data on the scup fishery of New York-Rhode Island are subjected to much inaccuracy because of the practices of the fishery and for which sufficient correction cannot be made, they do nevertheless reflect major changes in the catch.

Summary of Summer Fishery

1. The catch of scup has been subject to sharp fluctuations within a rather short period of time (1922-35). Beginning with a relatively high yield in 1922, the catch declined to a very low point in 1928 but recovered quickly, and in 1929 reached a level exceeding any previous record. The catch continued to increase each subsequent summer and reached a new record high level in 1935.

2. Total catch and catch per trap showed close agreement in time and magnitude, which indicates that the good catches of recent years were due to increased abundance caused by the successful spawning and survival of several successive broods.

3. The increase in yield in recent years (1929-35), as depicted by the total catch and catch per trap data, does not reflect the real magnitude of the abundance of scup because (1) large quantities were discarded at sea and (2) fishing effort was directed to other more profitable species because of the lack of profitable markets for scup.

4. The recovery of the scup fishery to a high level of abundance as a result of the successful survival of a brood spawned during a period when the large and old fish were not relatively numerous indicates that increase in abundance of this species is not necessarily dependent on the presence of a large spawning reserve of old fish.

5. The summer scup population appears to be divided into two groups: (1) An inshore stock composed of younger and smaller sizes and exploited by pound nets and (2) an offshore stock of fish about 4 years old, exploited by purse seines and otter trawls.

6. There are some indications that the fishery in northern New Jersey draws on a population unit separate from that of southern New Jersey. The separation is not quite distinct, however, for broods from northern New Jersey become available in the more southern fishery of the State.

7. The total catch of scup in this fishery has not shown as marked an increase since 1929 as has the New Jersey fishery. On the basis of catch per trap, both fisheries have experienced increases of about the same magnitude since 1931. This failed to be reflected in the total catch of New York-Rhode Island because depressed economic and market conditions caused a decrease in number of pound nets and traps.

8. The increase in catch per trap reflects increased abundance.

9. This increase has been the result of the appearance of large numbers of scup of the same age groups that were dominant in the preceding 2 years along the New Jersey coast, but the dominance of these broods was less marked in the New York-Rhode Island fishery, because at the latter points the fishery takes relatively more of the larger and older fish.

WINTER TRAWL FISHERY

Statistics of the Fishery

Changes in total yield.--The catch of this fishery is made entirely by otter trawlers fishing between the 20-fathom and the 100-fathom contours in the offing of the Virginia Capes (fig. 2). Because these winter catches of scup are credited to those States in which the home ports of the vessels are located and are combined with the summer catches by otter trawls in the coastal waters of those States, the published figures do not indicate the catch of this fishery separately.

A special series of records has been obtained through the cooperation of dealers, commencing with winter 1931, 2 years following the beginning of the winter otter trawl fishery. In 1931, data were obtained mostly from private bookkeeping accounts of principal dealers at Phoebus and Portsmouth, Va., at which ports the bulk of the catch was landed that winter. Pearson (1932) estimates that 80 percent of the catches were recorded in 1931. In 1932, standard record forms were supplied to the dealers at the principal ports

of landing for recording each trip and listing the quantities of each species landed. Most of the Virginia dealers complied, so that this series is virtually complete for the landings at Virginia ports, which received most of the winter catches each season after 1932. Lesser quantities of scup from the offshore winter fishery are landed at Cape May and Wildwood, N.J., and New York, N.Y., but unfortunately, the records of landed catches at these points are incomplete. Hence, the following discussion of the total yields is restricted to landings at Virginia ports. Because of their magnitude, it is believed that they depict the general changes in the fishery.

Although this offshore fishery is too new, and records of its catch cover too short a period (1931-35 inclusive) to establish a rend, they do afford an idea of the fluctuations that have occurred within this short period of five seasons. The total catch of scup has increased since 1931, rising from approximately 1,686,000 pounds in that winter to approximately 3,844,000 pounds in 1935 (figs. 3 and 8, table 16).

Total catch statistics of landings are for the period of November 15 of one year to April 15 of the following year. The fishery, however, takes place mainly in January, February, and March when most of the catch is landed. Hence, with the intention of avoiding confusion, a season is referred to as a single year, for instance, November 15, 1930, to April 15, 1931, is referred to as the winter of 1931.

Table 16.--Catch and catch per day's fishing, by the winter trawl fishery for scup, sea bass, and fluke, from statistics of landings at Virginia ports, 1931-35

[In pounds]

Species	Total catch[1]				
	1931	1932	1933	1934	1935
Scup	1,685,760	2,213,113	1,780,249	2,445,615	3,844,363
Sea bass	793,353	4,470,435	3,453,996	3,004,167	2,770,909
Fluke	935,553	2,643,216	1,705,440	2,355,033	3,067,440
	Catch per day's-fishing[2]				
	1931	1932	1933	1934	1935
Scup	6,240	2,643	1,336	4,008	2,846
Sea bass	1,151	3,424	4,270	3,836	2,515
Fluke	3,409	1,838	1,531	1,896	2,738

[1] November 15 of preceding year to April 15, inclusive.
[2] January to March, inclusive.

As might be expected in a new fishery, much of the increase has been due to increased fishing effort--the number of boats in the fleet increasing from about 50 in 1931 to 80 in 1932, 85 in 1933, 100 in 1934, and about 120 in 1935. Other factors besides increased fishing effort have caused changes in the catch.

Measurement of fluctuations.--In attempting to measure the magnitude of these changes in the catch of the winter trawl fishery, it is necessary to determine some unit of measure based on a fixed amount of fishing effort in order to eliminate whatever effect frequent changes in the amount of gear and fishing time may have on the landings. The selection of such a unit of measure sufficiently accurate to depict actual changes in the population was difficult because of the many factors that influence such a figure. The unit computed was the so-called "catch per day's fishing". It was intended to be the actual amount of catch as the result of 1 full day or 24 hours of actual fishing. Some of the factors affecting the accuracy of such a unit are (1) the discarding at sea of fish that the market may consider undersized and unsalable, together with the lack of accurate records or reliable estimates of the amounts and sizes thrown overboard; and (2) diversion of fishing effort at times from scup to more profitable and available market species (sea bass, fluke, and croakers). Such diversion is easily accomplished because market fish are more or less confined to certain areas within a few hours' steaming distance of each other (Nesbit and Neville, 1935). Diversion frequently occurs when fishing for scup is poor, when bad bottom results in too many net tearups, or when prices favor another kind of fish.

Also, fishing time is lost as a result of net tearups, vessel or equipment breakdowns, and cruising from one part of the ground to another, or to a distant port. Further difficulties arise because of differences in the size and power of boats, types of nets used, and mesh size. Annual changes in the fleet involved the inclusion of vessels that differ from each other in size, power, and catching efficiency. As might be expected in any new

fishery, increased knowledge of the grounds and habits of the fish has also been responsible for marked changes in type of gear and fishing practices. For instance, at the beginning of the fishery the flat net was used since this special type of trawl had proven efficient for dragging for fluke in the summer. However, with the discovery by the winter fishery of such fish as scup, sea bass, and croakers, along with fluke, experiments in modification of the flat net produced the balloon net, which was more efficient than the flat net for catching scup and sea bass. Since these fish continued to be found in commercial quantities exceeding those for fluke, the balloon net is now used almost exclusively by most of the boats engaged in the offshore winter fishery.

Account has been taken of these influences by computing catch per day's fishing from information obtained by personal interviews with the captains at time of landing: records of the locations of catch, amount of each kind of fish caught, diversion of fishing effort between the several species, and the kind, amount, and size of fish discarded at sea. Such attempts were not uniformly successful since it is difficult for the captains under ordinary fishing conditions to keep an accurate record (especially by memory) of these details.

There have been changes in the catch per day's fishing that appear to have been far in excess of any that could have been due to the deficiency of the fishing method. These changes suggest that major fluctuations in catch did actually occur and that the data reflect at least approximately the abundance or availability of the scup.

Although the total yield of scup in the winter fishery increased from approximately 1,686,000 pounds in 1931 to approximately 3,844,000 pounds in 1935--largely the result of an increase in the number of boats from 50 in 1931 to about 120 in 1935--the catch, as measured by catch per day's fishing showed marked fluctuations from year to year. For example, with the beginning of records in 1931, the catch per day's fishing was relatively high (6,240 pounds); in 1932 it declined (2,643 pounds); dropped very low in 1933 (1,336 pounds); rose in 1934 (4,008 pounds); and dropped again in 1935 (2,846 pounds) (fig. 9, table 16).

Causes of changes in yield.--Observations on the catches of the winter trawl fishery were made at the principal ports of landing in Virginia from 1931 to 1935 inclusive, and at Wildwood, N.J., in 1931, 1932, and part of 1933. When reduced appropriations necessitated curtailment of activities in 1933, the observations at Wildwood were discontinued, because that port received only a minor portion of the catch, and also because the sizes of the scup in catches landed at that port were more highly selected than those landed in Virginia. New Jersey vessels discard more of the smaller sizes of fish than do the Virginia boats, their markets having less ready sale for the smaller sizes of fish, especially scup and sea bass. Hence, consideration of fluctuations in yield of scup must be confined mainly to the information collected on landings at Virginia ports. This limitation is not overly severe, because these ports receive about 95 percent of the scup landed by the winter trawl fishery.

It was naturally expected that if the summer and winter fisheries drew on a common stock, the fluctuation in catch of the winter fishery might be due to the same changes in abundance as those occurring in the summer fishery. In an attempt to determine whether such was the case, we used an analysis of the length frequency method to identify and measure the relative importance of the annual recruitment to the stock available to the winter fishery. The analysis revealed that most of the winter catch included the same year classes that appear in the summer inshore pound net fishery and the summer offshore seine and trawl fisheries (fig. 8, table 17). The relative proportions, however, have not always been the same. In some winters, the younger scup characteristic of the New Jersey summer pound net fishery predominated in the winter catches, and in other winters, the larger sizes characteristic of the summer seine fishery were more important. For example, in the winter of 1931,

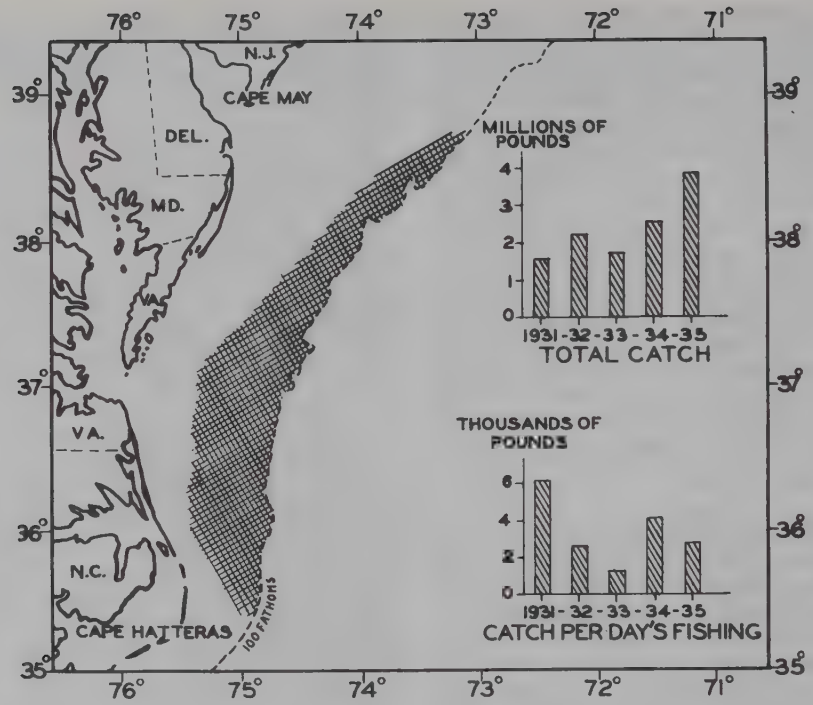


Figure 9.--Catch of scup by the southern winter trawl fishery, 1931-35.

the landings were composed mainly of large fish 25 cm. (10 inches) or more long and weighing from 3/4 to 2 pounds (Pearson, 1932). They were, in the main, fish spawned prior to 1927 and hence over 4 years of age. This distribution was of the same sizes and ages that composed the catch of the New Jersey trawlers and seiners the preceding summer (1930) (fig. 8). In the following winter (1932), younger sizes predominated. The catch landed in Virginia was composed mainly of small- and medium-sized fish with modal length values about 18 cm. (7 inches) and 22.5 cm. (9 inches), weighing from one-quarter to one-half pound, and being 1 to 3 years old. Observations at Wildwood, N.J., in winter 1932 revealed the discarding at sea of considerable quantities of scup below 20 cm. (8 inches, approximately), or most of the 1930 year class. It was not possible, however, to determine accurately from the interview records the amounts of the 1930 class discarded, although judging from the composition of the Virginia landings of scup it perhaps amounted to about 35 percent in numbers of fish. This discard was in accordance with the New Jersey vessel practice of discarding the smaller sizes. Although the New Jersey vessels frequently fish in somewhat more northern parts of the ground, principally for fluke, their scup catches are made for the most part in the same general region fished by the Virginia vessels. In contrast with the preceding winter, the 1932 winter fishery drew on the same year classes (1928 and 1930) and sizes that were prominent in the New Jersey inshore pound net fishery the preceding summer.

In the winter of 1933, the catch of scup landed at Virginia ports again consisted mainly of small and medium sizes and represented the same broods that had been present in the New Jersey inshore pound net fishery the preceding summer (1932). The fish were mostly of the 1930 and 1931 year class, the latter brood in the majority.

Table 17.--Length frequencies of scup from random samples of the catch of the winter trawl fishery landed at Virginia ports from 1931-35

[Numbers of fish]

Length	1931				1932[1]			1933[1]			1934[1]			1935[1]		
	Jan.	Feb.	March	Dec.	Jan.	Feb.	March	Jan.	Feb.	March[2]	Jan.	Feb.	March	Jan.	Feb.	March
Cm.																
8.5	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
11.0	-	1	-	-	-	-	-	-	1	-	-	2	2	-	-	-
11.5	-	-	1	-	1	-	-	-	1	-	1	-	-	-	-	-
12.0	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
12.5	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-
13.0	1	-	2	-	1	-	1	5	-	-	-	-	-	-	-	-
13.5	1	1	-	-	1	-	2	2	2	-	2	-	1	-	-	-
14.0	2	1	5	-	-	-	1	4	-	-	-	4	-	-	-	-
14.5	5	5	4	-	1	-	-	12	3	-	2	7	3	-	1	-
15.0	4	-	4	-	1	2	-	16	9	-	12	26	9	1	2	-
15.5	16	10	2	-	3	-	1	31	29	2	30	49	22	4	-	-
16.0	19	8	5	1	2	1	2	34	54	3	53	103	28	14	11	4
16.5	34	33	14	-	8	8	2	84	105	13	57	102	29	28	21	7
17.0	47	25	12	1	30	29	16	115	200	14	65	135	35	45	27	10
17.5	53	29	38	6	64	88	27	127	285	27	63	126	34	63	47	24
18.0	68	57	42	10	109	109	33	141	340	42	61	123	26	64	58	26
18.5	58	33	24	10	144	137	26	131	335	47	67	115	47	105	82	42
19.0	41	47	20	12	115	121	14	91	283	42	59	88	53	182	130	74
19.5	29	39	31	10	87	73	7	82	234	37	79	137	94	291	279	176
20.0	29	44	33	10	52	46	4	62	131	14	99	190	170	496	510	316
20.5	40	44	33	2	39	51	7	51	88	16	172	279	281	645	720	439
21.0	30	34	38	10	50	78	5	49	85	18	239	402	469	526	601	392
21.5	44	49	50	17	93	107	10	60	127	25	184	399	485	462	562	366
22.0	29	46	66	40	138	195	18	93	123	17	130	351	553	292	333	244
22.5	32	53	52	28	127	176	8	65	140	30	121	251	347	230	272	297
23.0	46	61	52	38	116	159	13	78	143	16	87	188	269	263	286	311
23.5	71	73	49	41	76	134	8	85	123	29	66	152	206	292	297	351
24.0	64	130	56	23	61	113	10	95	151	17	54	147	179	209	225	331
24.5	87	93	61	23	48	81	9	95	134	21	73	135	206	166	159	195
25.0	80	127	100	22	50	104	8	90	106	24	64	151	228	114	122	176
25.5	79	147	133	18	49	103	9	70	104	25	65	165	261	112	126	155
26.0	86	129	113	11	29	92	5	65	68	18	62	169	264	90	129	167
26.5	86	133	123	5	25	78	3	45	75	14	57	138	246	101	131	204
27.0	93	135	123	3	24	69	7	32	70	16	49	132	206	81	111	175
27.5	90	132	119	6	15	61	4	34	53	7	40	94	144	79	92	172
28.0	97	175	167	10	11	60	2	27	30	9	35	67	129	55	66	119
28.5	106	129	147	12	11	53	4	22	39	5	27	68	103	66	54	120
29.0	85	198	150	6	6	42	4	21	27	9	27	48	91	32	53	80
29.5	61	167	111	8	8	25	3	14	29	2	21	41	80	35	32	77
30.0	66	167	118	1	7	29	-	13	24	7	21	35	72	22	36	59
30.5	52	180	78	5	6	22	-	14	32	6	19	35	64	27	17	52
31.0	42	166	99	5	8	21	4	12	23	1	21	32	58	18	13	47
31.5	48	161	65	-	11	8	2	12	24	7	17	30	83	24	24	52
32.0	49	129	52	1	4	6	5	9	24	3	13	25	71	11	17	36
32.5	45	118	48	2	2	7	-	5	10	4	8	23	42	13	24	40
33.0	30	127	28	-	2	4	2	4	10	-	16	19	51	10	10	20
33.5	25	121	17	-	1	3	2	7	7	3	6	13	39	15	9	23
34.0	17	117	24	-	1	2	-	2	1	2	4	7	25	7	15	13
34.5	24	64	13	-	-	1	1	1	6	-	4	11	20	6	6	11
35.0	10	64	8	-	-	3	1	-	4	5	1	3	9	5	6	8
35.5	11	42	7	-	-	1	-	4	1	2	3	7	19	6	3	6
36.0	2	31	6	-	2	-	1	-	2	2	-	4	6	-	3	8
36.5	3	32	-	1	-	-	-	1	2	-	3	2	4	-	1	2
37.0	3	19	6	-	-	-	-	1	-	2	2	5	5	-	2	1
37.5	2	22	-	-	-	-	-	-	-	-	-	4	4	2	-	-
38.0	-	16	2	-	-	-	1	-	1	-	1	1	4	1	1	2
38.5	-	16	3	-	-	-	-	-	-	-	1	2	3	1	-	-
39.0	-	12	-	-	-	-	-	-	-	-	-	1	-	-	-	2
39.5	-	20	1	-	-	-	-	-	1	-	-	-	-	-	-	1
40.0	-	3	-	-	-	-	-	-	-	-	-	1	1	1	-	-
40.5	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
41.0	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41.5	-	4	-	-	-	-	-	-	-	-	-	-	1	-	1	-
42.0	-	10	-	-	-	-	-	-	-	-	-	-	2	-	-	-
42.5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.0	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.5	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45.0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45.5	-	1	-	-	--	-	-	-	-	-	-	-	-	-	-	-
46.0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47.0	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48.5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2,143	4,066	2,557	398	1,639	2,502	292	2,113	3,900	603	2,364	4,842	5,884	5,312	5,727	5,433

[1] Samples from catches sorted at sea into size categories converted statistically to equivalent of random samples, base 100 fish, of unsorted catches.
[2] To March 15.

Summer data were not available for comparing the winter catch of 1934 with the summer catch of 1933, but comparison of size composition of the catches in the winter of 1934 can be made with that of the preceding winter. In 1934 the composition of the landed catches again changed markedly, for compared with 1933 relatively more medium and large fish were present. The medium sizes were mostly of the 1931 brood that had been prominent as small fish in the preceding winter. This change could be expected because similar progression of broods into the larger market categories with increase

in age and growth had been observed in the summer fishery (fig. 6). The increase in numbers of large fish (25 cm. and more, 1930 year class and older) was greater than was expected on the basis of their relative importance in the preceding winter.

Small-sized fish were very numerous, however, in 1934, for considerable quantities both of undersized and of legal-sized fish were reported discarded at sea because no market existed. From fishermen's estimates of size and from a few samples of measurements obtained at sea, it was learned that these discards were mostly of the 1932 brood, supplemented by lesser numbers of the 1933 brood.

It was estimated that of a total catch of approximately 2.4 million pounds of scup made by vessels landing at Virginia ports in January, February, and March of 1934, more than 500,000 pounds, or 20 percent, were discarded at sea. Expressed in numbers of fish, of a total catch of approximately 4.7 million scup, about 1.9 million fish, or 40 percent, were destroyed and discarded. Because of lack of observations in New York and New Jersey, it was not possible to estimate reliably the number of small fish discarded from the catches landed at these ports, but since small fish are less acceptable in these markets than in Virginia, it is probable that the proportions were even higher.

In the winter of 1935, the age and length composition of the landed catches was similar to that of 1934. The 1932 year class, which accounted for most of the scup discarded in 1934, figured prominently in the catch of 1935 under the market cull of "small", and the 1931 year class moved into the "medium" market category after being present in the preceding winter (1935) as "small" (fig. 8). The most striking difference between the 1934 and 1935 catch was the relatively small quantity of the smaller sizes of scup reported discarded during winter 1935. In that winter, most of the discarded fish of this size group were presumably the 1933 brood. Hence, the lack of reports of any considerable discarding indicated that the 1933 year class was actually less numerous than the 1932 year class in that area at that time.

The magnitude of these shifts in the size composition of the catches in each of the past several winters is shown more strikingly on the basis of length data weighted to make them proportional to the number of fish landed in total catch and to catch per day (fig. 8, tables 18 and 19). They revealed that the total catch in number of fish increased steadily from 1931 to 1935. Much of this increase was due to increasing fishing effort by a larger fleet. The shifts of fish from larger sizes in 1931 to smaller sizes in 1932 and from smaller sizes in 1933 to larger sizes in 1934 and 1935 are also obvious from figure 8.

These sharp changes in size composition were reflected in the catch per day's fishing. For example, when the size composition of scup catches shifted from large sizes in 1931 to smaller sizes in 1932, the catch per day's fishing also dropped from 6,240 pounds in 1931 to 2,643 pounds in 1932 (fig. 9, table 16). Similarly, in 1933 when the small sizes continued to be relatively more important than the larger sizes, the catch per day's fishing remained low and even dropped to 1,336 pounds. In 1934 when the number of medium fish increased compared to 1933, the catch per day increased to 4,008 pounds. In 1934, however, as previously described, the small sizes were exceptionally numerous and, for the most part, discarded. If they had been retained as part of the landed catch, the catch per day's fishing would undoubtedly have been much higher. In 1935, although small fish (about 17.5 cm.) were relatively less numerous than in 1934, the number of large fish was relatively more numerous, the latter undoubtedly helped materially in preventing the catch from declining to a much lower point than 2,846 pounds per day.

From the foregoing discussion, it appears that the yield of the winter fishery in the short period of five winters (1931-35 inclusive) has fluctuated sharply as evidenced by erratic changes in catch per day's fishing and by marked differences in size composition of the catch. If the principal cause of changes

Table 18.--Length of scup in the catch of the winter trawl fishery landed at Virginia ports, 1931-35, weighted according to the quantities landed

[Numbers of fish, in thousands]

Length	1931	1932	1933	1934	1935	Length	1931	1932	1933	1934	1935
Cm.						Cm.					
17.0[1]	17	130	115	82	20	31.5	47	23	15	35	34
17.5	24	245	161	73	36	32.0	40	38	9	28	22
18.0	32	353	215	63	39	32.5	36	3	8	20	26
18.5	23	360	209	65	60	33.0	30	16	3	24	12
19.0	20	255	161	53	103	33.5	25	15	6	16	15
19.5	18	155	137	79	217	34.0	24	-	4	10	11
20.0	19	98	68	117	382	34.5	17	7	1	9	8
20.5	22	94	64	192	518	35.0	12	8	6	2	5
21.0	19	86	58	290	443	35.5	9	-	4	7	5
21.5	27	156	80	278	405	36.0	5	7	3	2	4
22.0	27	262	73	282	259	36.5	5	-	-	3	-
22.5	26	193	95	194	257	37.0	4	-	3	2	2
23.0	30	212	72	144	269	37.5	3	-	-	2	-
23.5	38	133	86	112	293	38.0	3	7	-	2	-
24.0	45	133	75	100	248	38.5	3	-	-	-	-
24.5	47	122	76	108	161	39.0	2	-	-	-	-
25.0	59	111	75	120	135	39.5	3	-	-	-	-
25.5	68	120	72	131	123	40.0	1	-	-	-	-
26.0	62	73	56	134	126	40.5	1	-	-	-	-
26.5	64	54	53	117	144	41.0	1	-	-	-	-
27.0	66	86	45	103	124	41.5	1	-	-	-	-
27.5	64	50	24	72	116	42.0	2	-	-	-	-
28.0	81	31	24	62	81	43.0	1	-	-	-	-
28.5	74	46	17	52	76	43.5	1	-	-	-	-
29.0	79	37	21	44	57	44.5	1	-	-	-	-
29.5	61	27	11	38	48	47.0	1	-	-	-	-
30.0	64	8	15	34	40						
30.5	53	5	17	30	31	Total	1,560	3,801	2,244	3,360	4,983
31.0	53	42	7	29	28						

[1] Fish below 17.0 cm. (approximately) were discarded by dealers as unsaleable.

in yield were changes in abundance, it would be expected that the changes in size composition would involve principally changes in the relative importance of the annual increments of young fish as was the case in the summer fishery. The best catches of the winter fishery, however, were in years when the large fish were relatively more important (1931, 1934, 1935, figure 9); and further, that the relative importance of the several size groups that composed the catch not only differed when one winter was compared to another, but underwent erratic changes even within a season. The latter, in particular, suggests that fluctuations in the catch resulted from changes in availability rather than changes in abundance.

Hydrography

The principal causes of the changes in availability of scup in the winter fishery may be found in the hydrographic studies of the winter trawl fishing area. It is not surprising to expect that differences in water temperature should affect the movements and behavior of fish in the winter trawl fishery, since their seasonal migrations appear to be closely related to temperature changes. With the chilling of the inshore waters in fall, the fish leave their summer grounds and migrate to winter regions where temperatures are about as high as the lowest found in the summer fishing grounds along the inshore coastal waters. Likewise, with the warming

Table 19.--Length of scup in the catch of the winter trawl fishery landed at Virginia ports, weighted according to the quantities landed on catch per day's fishing per trip basis, 1931-35

[Numbers of fish]

Length	1931	1932	1933	1934	1935	Length	1931	1932	1933	1934	1935
Cm.						Cm.					
[1] 17.0	65	91	122	90	12	31.5	166	16	17	38	20
17.5	92	167	171	80	22	32.0	144	27	10	32	13
18.0	121	233	232	69	23	32.5	130	2	9	22	15
18.5	90	230	226	72	36	33.0	103	12	3	27	7
19.0	73	158	174	60	62	33.5	83	11	7	18	9
19.5	67	95	198	88	129	34.0	79	-	4	11	6
20.0	71	60	73	130	226	34.5	57	5	1	10	4
20.5	83	62	70	214	304	35.0	40	6	7	2	3
21.0	74	53	63	323	260	35.5	29	-	4	8	3
21.5	102	100	87	309	236	36.0	15	5	4	2	2
22.0	101	168	79	315	152	36.5	13	-	-	2	-
22.5	100	118	104	216	150	37.0	13	-	4	4	1
23.0	119	135	78	160	158	37.5	8	-	-	2	-
23.5	152	83	93	124	172	38.0	7	5	-	2	-
24.0	171	86	80	111	146	38.5	7	-	-	-	-
24.5	185	80	82	121	95	39.0	3	-	-	-	-
25.0	227	73	82	133	79	39.5	7	-	-	-	-
25.5	258	78	79	146	72	40.0	1	-	-	-	-
26.0	239	47	61	150	73	40.5	1	-	-	-	-
26.5	242	33	58	131	84	41.0	3	-	-	-	-
27.0	248	57	49	114	72	41.5	1	-	-	-	-
27.5	239	33	26	80	68	42.0	3	-	-	-	-
28.0	301	20	27	68	48	43.0	1	-	-	-	-
28.5	283	30	18	58	45	43.5	1	-	-	-	-
29.0	289	25	22	49	33	44.5	3	-	-	-	-
29.5	221	19	11	43	28	47.0	1	-	-	-	-
30.0	272	4	17	38	23						
30.5	191	2	19	35	18						
31.0	187	24	7	32	16	Total	5,782	2,453	2,478	3,739	2,925

[1] Fish below 17.0 cm. (approximately) discarded by dealers as unsaleable.

of the coastal waters in spring, fish make a return migration from the winter habitat to the inshore summer fishing grounds.

The study of hydrographic conditions is based principally on serial water temperatures collected by the Bureau's vessel *Albatross II* in the winters of 1929-32, by the Woods Hole Oceanographic Institution research vessel *Atlantis* in the winters of 1933 and 1934, and by surface and bottom water temperatures collected through the voluntary cooperation of various fishing captains in the winters 1933-35, inclusive. On the fishing vessels, observations were limited to bottom and surface only. Since scup as well as sea bass and fluke are caught on or near the bottom in the winter trawl fishery, the temperature of the water at or near the bottom is referred to in the following discussion.

The general sea bottom of the Atlantic coast extending from Cape May to Cape Hatteras (lat. 39° N. to lat. 35° 10' N.), the region frequented by the winter trawl fishery, is marked by its smoothness and gradual slope (Bigelow, 1933). The breadth of this submerged plain from the land out to the 100-fathom contour is about 70 miles off Cape May, about 60 miles off Chesapeake Bay, and about 20 miles off Cape Hatteras. From the shore, it slopes gradually until a depth of 50 to 100 fathoms is reached. Beyond the 50- to 100-fathom zone, there is a more abrupt drop in the ocean bed, with depths of 300 to 400 fathoms recorded 5 to 10 miles beyond the edge of the Continental Shelf. Beyond this is a region of still deeper water extending down to the abyssal depths of the ocean.

Nesbit and Neville (1935) state:

In this very deep water, the bottom temperatures are very low the year round. Inshore of this area of cold water is a zone of water between the 40 and 150-fathom depths warmed from surface to bottom by the Gulf Stream throughout the winter. Thus, there is a narrow band of relatively warm bottom water present throughout all winters (of which we have record) following in general the 100-fathom line extending from abreast of Cape Hatteras to at least abreast of Cape May and even continuing to abreast of Cape Cod and along the southern edge of Georges Bank. In contrast to this band of water which is warm both in winter and in summer, the water covering the wide inshore submerged plain out to about the 40-fathom depth is subject to great seasonal changes, for here the temperatures are high in summer, but in winter the water is chilled to a greater or less degree from surface to bottom.

This cooling begins in the fall and takes place from inshore to offshore. In reference to this, Bigelow (1933) states:

In late autumn and early winter, cooling proceeds most rapidly near the land. By mid-December the water is coldest inshore, surface to bottom; the thermal pattern is of the winter type with the isotherms (lines of equal temperature) paralleling the coastal trend at all depths; and a cold inshore boundary has been re-established to the bottom water warmer than 8°-9° C. (46°-48° F.) that washes the edge of the continent. By the middle of the month, mean temperatures are about 5°-8° C. (41°-46° F.) along shore, and 10°-13° C. (50°-55° F.) along the outer edge of the shelf (100 fathom line) . . . and with vertical equalization so nearly complete that the difference between surface and bottom is in most cases less than 0.5° C. (0.9° F.) at given stations.

Cooling proceeds through January until, by the end of the month, the temperature, surface to bottom, has ordinarily fallen below 5°-6° C. (41°-43° F.) all along the coast; to 8°-9° C. (46°-48° F.) midway out on the shelf; but is still 10°-12° C. (50°-54° F.) along the outer edge of the latter. And cooling continues through the later winter until the minimum for the year is reached late in February, or early in March, ...

No thermal evidence has been found of any widespread influx of warm coastal water into the region (Chesapeake Bay to Cape Cod) from the south (below Cape Hatteras) of any floodings of the surface with pure oceanic water of high temperature, nor of upswellings onto the shelf of the cold abyssal water, such as have sometimes been postulated in the past on theoretic grounds.

The amount of chilling on the shelf between Cape Hatteras and Cape May has differed considerably in each of the past five winters (1931-35). The extent of the zone of relatively warm water tolerated by the species has also differed in one winter compared to another winter, for obviously the width of this zone will be less during a cold winter than during a warm winter. It follows, therefore, that in some years the fish have been more or less confined and, hence, concentrated in a relatively small area, while in other years when cooling has been relatively less, the zone of warm water has extended over a wider area, and the fish are free to move over a larger expanse of sea bottom. This has been clearly demonstrated by comparing the localities of best fishing with the zone of water warmer than 45° F., the latter being assumed a reasonable low temperature limit, but by no means the absolute limit tolerated by the fish (figs. 10 and 11).

During the winter of 1931, the water over the entire shelf was chilled, and by the early part of March the zone of bottom water warmer than 45° F. was confined to a narrow band lying beyond the 40-fathom line. Scup, sea bass, and fluke were confined to water out near the edge of the shelf and to depths greater than 40 fathoms where the water was 45° F. or warmer. In the following winter (1932), the inshore shoal water did not cool to such low temperatures as in the previous winter, and relatively warm water was present over a much greater extent of sea bottom. In that winter, scup, sea bass, and fluke were not driven as far offshore by water colder than 45° F., and the best catches were made much farther inshore and in water more shoal than in the winter of 1931. In the next winter (1933), water temperature conditions were about the same as in the previous winter (1932), and the best fishing was also in about the same location.

Nesbit and Neville (1935) state:

In the past winter (1934) there was a combination of the conditions of the three previous winters. The early part of the season (January) the water was relatively warm, resembling 1932 and 1933, but the latter part (March) the water was relatively cool, resembling 1931. Although air temperatures were low in January, there had not been time for any considerable cooling of the water, for the zone having bottom temperatures warmer than 45° F. apparently still extended over about the same general area as in the previous two

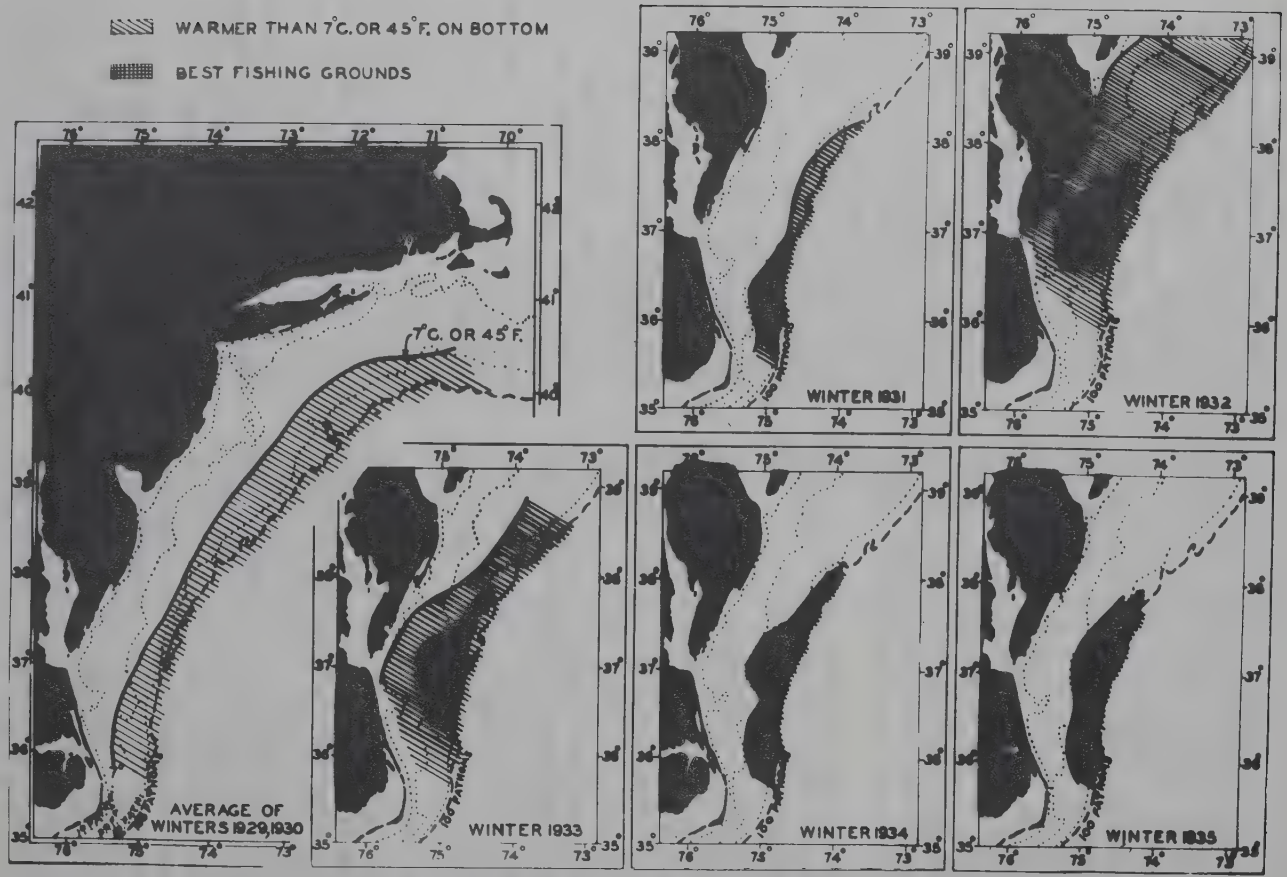


Figure 10.--Comparison of changes in temperature of water at or near the bottom with changes in location of best fishing: southern winter trawl fishery, 1931-35.

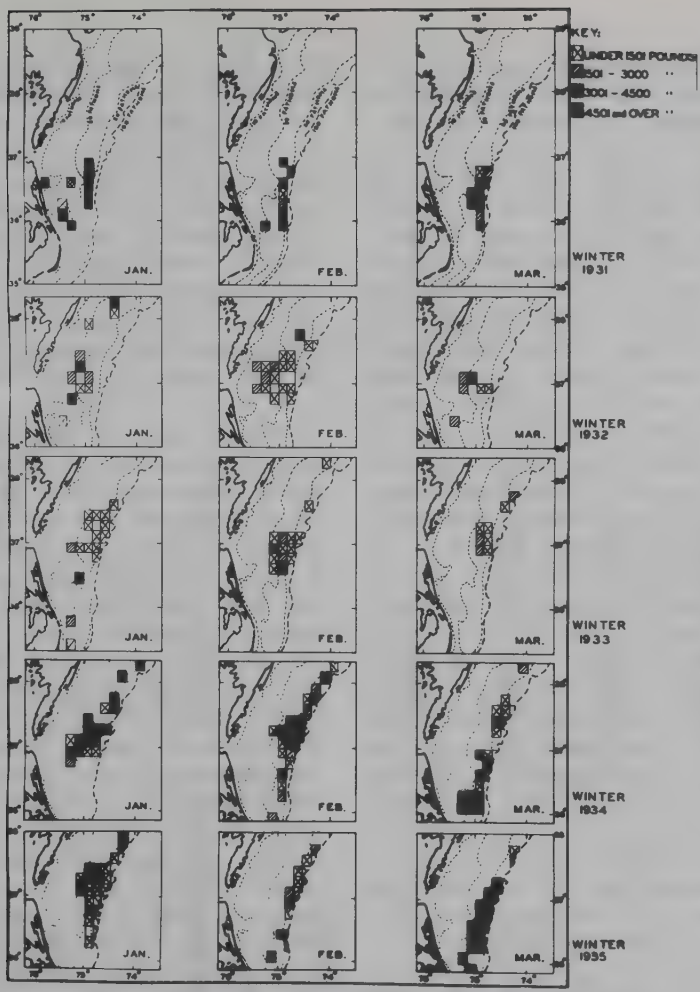


Figure 11.--Concentration of scup based on catch per day's fishing in the southern winter trawl fishery from 1931-35.

winters (1933 and 1932); and scup, sea bass, and fluke were in the more inshore, shoal region, the best catches being made in about the same location as in 1933 and 1932. In February, however, the continued severely cold weather resulted in a distinct chilling of the water so that the fish were driven to more offshore, deeper, and warmer regions beyond the 45- and 50-fathom lines. In March, as a result of the continued cold weather throughout the previous month and the first part of March, water temperatures continued to drop; and scup, sea bass, and fluke were found not only farther offshore and in still deeper water, but also to the southward. Water temperatures taken in the early part of March indicated that the zone of bottom water 45° F. was confined beyond the 50-fathom line in the more northerly part of the ground (38° latitude), but extended inshore to about the 25-fathom line in the southern part (36° latitude). In the northern area fishing became poorer either because the scup, sea bass, and fluke were driven so far offshore and to such depths that they were beyond the reach of the gear of the majority of the fleet, or because of migration to the southern area. The fishing shifted to the southern part of the ground, where the zone of relatively warm water was present over a more inshore and shoaler area. In March, both the location of fishing and the zone of bottom water 45° F. approximated the condition existing in the winter of 1931.

In 1935, water temperatures by the end of the winter (first part of March) were about the same as in the preceding winter. The temperature data for 1935 were mainly from a single trip aboard a dragger fishing the central portion (easterly of Chesapeake Lightship)

of the general offshore region, during which temperatures were taken at several stations on a profile extending from about the 10-fathom line out to the 100-fathom contour. These data were supplemented by temperatures taken by certain fishing captains at various fishing spots in the general area from about lat. 36° N. to about lat. 38° N. in depths 40 to 60 fathoms. The sharp drop in temperature did not occur in February as was the case in 1934; instead, there were indications of a gradual cooling from January through to March, so that by the latter month the zone of water 45° F. or warmer covered about the same extent of sea bottom, at least off Chesapeake Bay, as in 1934. There was, however, in 1935 a shift in best fishing location from a somewhat central inshore area, depths 20 to 50 fathoms, in January to a more offshore area extending more to the north and south in depths of 50 fathoms or more in February. In March, fishing continued to be offshore, but with some shift to a more southerly inshore area, with 20- to 50-fathom depths (fig. 11). Thus, there was general correspondence to the changes in fishing locations in 1934. Likewise in 1935, as in 1934, fishing in the northern area yielded smaller catches per unit of effort in March than in January or February; and in the southern area, on the other hand, catches were better in March than in the preceding months.

Not only have the marked changes in water temperature affected the location of best fishing, but it also affected the proportions in the catch of scup, sea bass, and fluke and, in some years, croakers. Obviously, the fleet is not particularly interested in any one species, but rather in the amount of money that can be made. Sea bass and fluke usually bring a higher price than scup or croakers, and special effort is often directed toward the former two species. If sea bass and fluke are not easy to catch, fishermen do not hesitate to seek scup or croakers (the latter especially in March) when they are readily available and numerous.

We have already seen that the best catches have been made in bottom water warmer than 45° F. (figs. 10 and 11). This was especially true of the scup catches. For example, in 1931 when the zone of warm water was confined to a rather narrow band far out near the edge of the Continental Shelf, good catches were made in the southern offshore part of the ground. In that winter, more scup than sea bass or fluke were caught. Of a total catch of approximately 3,415,000 pounds landed at Virginia ports, about 50 percent was scup, 23 percent sea bass, and 27 percent fluke. On the basis of catch per day's fishing for the season, scup also exceeded either of the other two species (fig. 12, table 16).

The dominance of scup in 1931 might have been the result of (1) hydrographic conditions which concentrated scup in the southern inshore shoal portion of the zone of water 45° F. or warmer, where they were readily available to the gear, and (2) the lesser availability of sea bass and fluke, which favor somewhat different areas than scup, probably because of preference for slightly different temperature and bottom type. Observations from 1931 to 1935 have revealed that the best catches of sea bass are usually taken in deeper and slightly warmer water than are scup and on rocky bottom in contrast to smooth, hard, sandy bottom frequented by scup. The best catches of fluke are usually from deeper water than are scup, but unlike either sea bass or scup, fluke are caught in more northerly part of the ground on soft, smooth, mud bottom (about lat. 37° N. to about lat. 38° 30' N., 40 to 80 fathoms). It is probable that the preference of each species for a special kind of bottom modifies the movements of the fish affected by changes in temperature, for although the water over a region may have a temperature tolerated by the species, the latter may not remain there for any length of time if the bottom is not suitable.

The best catches of croakers in some years are made in December in the region of relatively warm and shoal water south of Cape Hatteras, but in other winters (as in 1934 and 1935) best catches were made in March from near the beach, out to about the 50-fathom line. It is believed that this is part of the spring migration to the summer fishing grounds, for by the end of March large catches are often taken by traps in the inshore

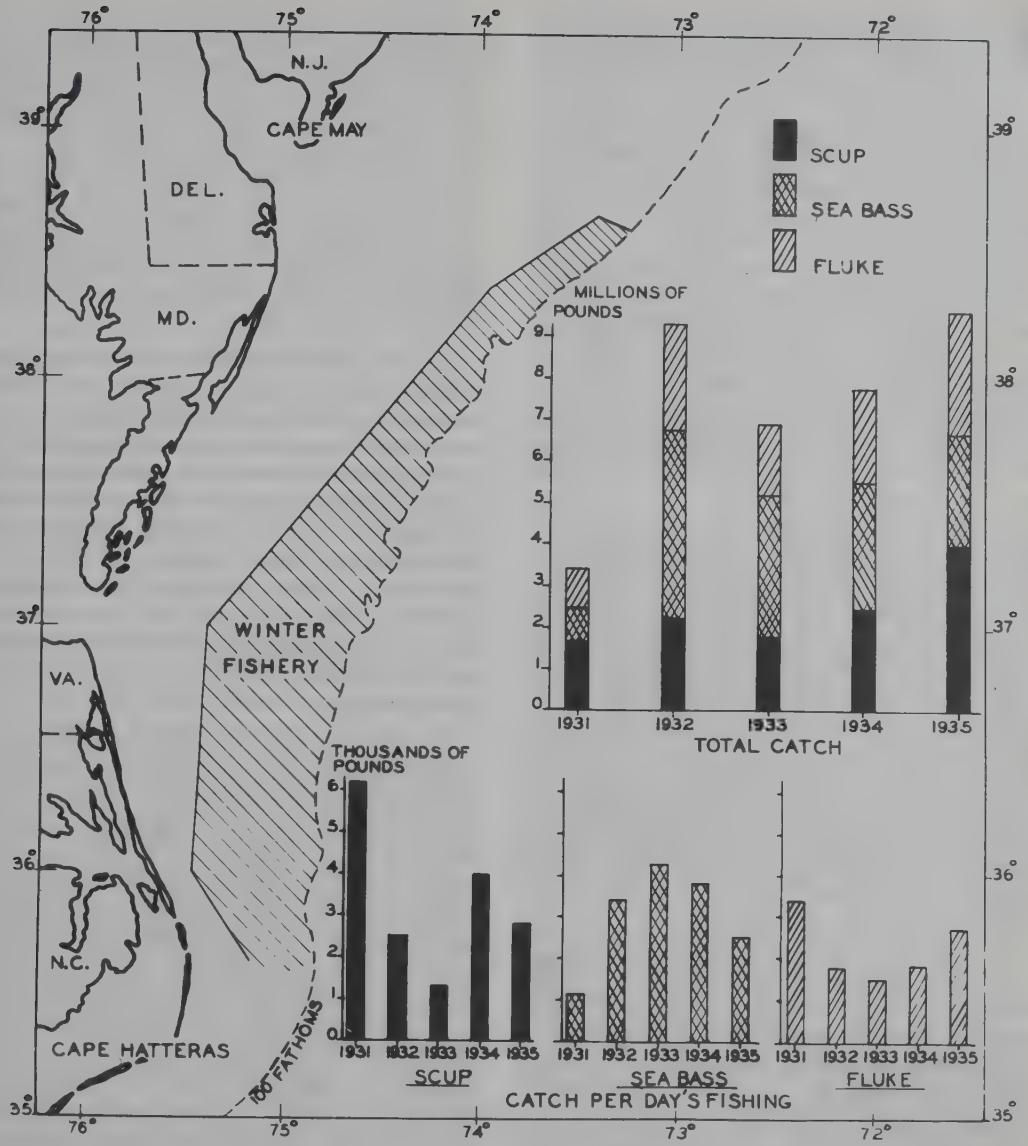


Figure 12.--Total catch and catch per day's fishing of scup, sea bass, and fluke, 1931-35.

waters a few miles south of the mouth of Chesapeake Bay in Virginia (fig. 2).

In the winter of 1932, when the entire body of coastal water from Bodie Island to Cape May (lat. 36° N. to lat. 39° N.) had not cooled to low temperatures as in 1931, the zone of bottom water warmer than 45° F. was far inshore, resulting in a great increase of area in which the scup lived. That the scup scattered widely over the region is indicated by the small catches at spots scattered over the general region and the failure to find large concentrations in any special part of the ground. This temperature change also affected the movements of sea bass and fluke because they were not drived as far offshore as in the preceding winter and hence could

and did remain in this more inshore shoal area. However, they did not scatter over as extensive an area as did the scup and were more readily available. Because of this, the catch per day's fishing of sea bass increased approximately threefold between the winter of 1931 and 1932 and exceeded that of scup, which declined about 42 percent between the two winters (fig. 12). The combined total catch of all three species increased in 1932, partly as a result of the greater availability of sea bass and partly from a greater number of trips by a greater number of boats, the fleet increasing from about 50 vessels in 1931 to about 80 in 1932. Of total landings of approximately 9,327,000 pounds in Virginia in 1932, about 24 percent was scup, 48 percent sea bass, and 28 percent fluke.

In the next winter (1933), hydrographic conditions were similar to 1932; the zone of water 45° F. or warmer was widespread, scup did not concentrate, and the catch per day's fishing dropped even below 1932 (50 percent). Much of the effort was directed toward sea bass, which were again present in about the same area as in the previous winter, but in even greater numbers either because of increased availability or actually increased abundance, with the result that the catch per day's fishing increased 25 percent over 1932 and again exceeded the average catch per day's fishing for scup.

The total yield of scup, sea bass, and fluke landed at Virginia ports showed a decline, however, in 1933 as compared to the preceding winter. Although the number of boats increased slightly in 1933, fewer trips were made because of unusually frequent storms which interfered with or prevented fishing for extended periods throughout the season. Hence, although the catch per day increased, the total yield decreased. As in 1932, sea bass continued to dominate the fishery. Of a total catch of approximately 6,940,000 pounds landed in 1933, 49 percent was sea bass, 26 percent scup, and 25 percent fluke.

In winter of 1934 the marked changes in hydrographic conditions within the season were accompanied by equally important changes in fishing location and amount and kinds of fish caught. In January, when relatively warm bottom water was present over a rather wide expanse of inshore coastal area, most of the fishing was done in about the same inshore shoal region as in 1933. Scup were again caught over a wide area, but were either more abundant or more readily available than in 1933, as indicated by the greater catch per day's fishing in January 1934 than in the previous January. Sea bass and fluke were caught in about the same area as in 1933.

In February with sudden, sharp cooling of the inshore water, scup, sea bass, and fluke were driven to offshore, warmer regions and became more concentrated. Consequently, the fishing shifted to the more offshore grounds in depths of 40 fathoms or more, and the catch per day's fishing of all these species increased. The catch of scup exceeded that of either sea bass or fluke, indicating that scup were probably more inshore and more available than sea bass and fluke, the majority of which were perhaps in deeper water than that generally frequented by the scup.

By March, as a result of the inshore waters being cooled to such a degree by continued low air temperatures throughout February, the zone of water 45° F. or warmer was forced well offshore to the position it was in the winter of 1931 (fig. 11). Scup, sea bass, and fluke were confined to even more offshore, deeper sea bottom within this zone of relatively warm water than in the preceding month. Moreover, the fishery moved to the same area in the southern part of the grounds as that fished in 1931, and good catches consisting mainly of scup were made in depths of 30 fathoms or more. In addition, in March the average catch per day's fishing computed on landed catches was larger in the southern part of the ground.

Sea bass and fluke, on the other hand, continued to be sought in March in the offshore central and northern parts of the ground in depths of 50 fathoms or more, and some good catches were made. It is probable, however, that the majority of sea bass at least were far offshore and in depths beyond reach of the gear, as was probably also the case in the cold winter of 1931.

As a result of the effect of these hydrographic changes on fishing locations and on availability, the catch of scup per day's fishing for the season as a whole showed a marked increase in 1934 compared to 1933; for sea bass, a decrease compared to 1933; and for fluke, little change compared to the previous year. The total catch of scup, sea bass, and fluke landed in Virginia increased in 1934 compared to 1933, probably largely as a result of (1) increased fishing effort by additions to the fleet, the number of boats increasing from about 85 in 1933 to about 100 in 1934; and (2) greater availability of scup, especially in March with diversion of much of the fishing effort to this species. In contrast with previous winters, the composition of the total catch was more evenly balanced among the three species, for of approximately 7.8 million pounds landed in Virginia in 1934, 38 percent were sea bass, 32 percent scup, and 30 percent fluke (fig. 12).

In winter of 1935, observations indicated a gradual cooling of the inshore water during January and February, and by March the zone of bottom water warmer than 45° F. was confined to about the same offshore region as in the latter part of the preceding winter (fig. 10). As in 1934, this continued chilling from inshore to offshore resulted in the movement of scup, sea bass, and fluke to more offshore regions of warmer water. In January fishing was in about the same inshore shoal area (depths 20 to 50 fathoms) as in 1934 (fig. 11) with more sea bass being caught than scup or fluke; in February, with the continued chilling of the water, fish were driven farther offshore to depths of 50 fathoms or more with sea bass farther offshore and less available than the scup, which were somewhat more concentrated inshore of the bass. As a result, the catch per day's fishing of the former declined while that of the latter increased. In addition, good catches of fluke were made in the more northerly part of the offshore area, the catch per day's fishing exceeding that of the scup and of the sea bass.

In March, fishing continued in the offshore, deeper area (depths of 50 fathoms or more) in the zone of 45° F. water. Sea bass were difficult to catch, probably because of their concentration in depths too great to be fished by most of the vessels and because of their preference for a region of hard rocky bottom on which considerable tearing-up of the gear occurred. Consequently, much of the effort was directed to fluke in the more northerly part of the ground where fair catches were made, and to scup concentrated inshore of the sea bass in depths 30 to 55 fathoms, as well as in the southern area in depths 20 to 50 fathoms where they could be easily reached by the gear and were in such concentrations that good catches were made (fig. 11). In March the catch per day's fishing for scup was higher than in January or February and exceeded the catches of sea bass and of fluke, both of which showed a decline compared to February.

In 1935, as a result of the delayed cooling of water and the lesser abundance of the smaller sizes, the catch per day's fishing of scup decreased compared to 1934. Catch per day's fishing of sea bass also declined; fluke, on the other hand, showed an increase over the preceding winter (fig. 12). The total yield of scup, sea bass, and fluke landed in Virginia reached a record high in 1935; and for the first time since 1931, scup accounted for the greater part of the total catch. Of the 9,683,000 pounds landed, 40 percent were scup, 28 percent sea bass, and 32 percent fluke. This increase in total catch resulted from increased fishing effort by a somewhat larger fleet in 1935 (about 120 vessels compared to about 100 in 1934).

The winter of 1935 marked the first appearance of a new type of vessel in the southern trawl fishery, the *Boston College*, which previously had been regularly engaged in year-round fishing principally for haddock and cod on Georges Bank and vicinity in the North Atlantic. She was launched in 1928 and is one of the larger and more modern trawlers, being 114 feet long with a gross tonnage of 241 tons and carrying a crew of about 20. Under the command of Leo Faralora, an experienced southern winter trawl captain, she fished mainly for sea bass. Her heavier gear and specially rigged nets gave her the advantage over the rest of the fleet of smaller, lighter equipped vessels, because she could fish the

deeper, rocky sea bottom where the sea bass were concentrated. When spots of good fishing are once found, the trawler could stay on these locations longer by means of her modern depthfinder.

Although the trips by the *Boston College* averaged a day longer than the rest of the fleet of small boats, her catches consistently were three to four times greater than the average for the smaller vessels. Because of the possible selection due to difference in size and modification in gear, size of vessel, and greater efficiency through more modern equipment, her catches have been analyzed separately from the rest of the fleet and included with them only in total catch statistics. Observation of her landed catches revealed about the same size composition as those of the other smaller vessels; her total catch and her catch per day's fishing, however, were materially higher because of her larger nets.

Having shown that the changes in hydrographic conditions were accompanied by erratic changes in catch per day's fishing, it remains to point out that the marked changes in the size composition of the catch previously described were regularly associated with changes in water temperature, indicating that the latter had caused the fish to move about. For example, during the "cold" winter of 1931, when the zone of water 45° F. or warmer was relatively narrow, the principal catches of scup were in the southern part of the ground and consisted of relatively more large fish than small (fig. 8). In the following two "warm" winters (1932 and 1933), when the zone of water 45° F. or warmer extended over a comparatively large extent of sea bottom, catch of scup consisted mostly of small and medium sizes. The scup apparently scattered over the area and were less available than in 1931, as indicated by the decline in catch per day's fishing in 1932 and 1933 compared to 1931 and by increase in area of the plots of the localities of catch (figs. 10, 11, and 12).

With the sudden chilling of the water in February 1934, the zone of warm water in March was a narrow strip out over the edge of the shelf, similar to the condition in 1931. The size composition of the catch in this southern area consisted of relatively more of the large scup. This was in direct contrast to January before the cooling began when the band of warm water presumably was present well inshore, in which area the scup catches were mainly small and medium fish.

In 1935 the cooling of the water was more gradual from January to March when by the latter month the zone of 45° F. or warmer water was over about the same narrow region as in 1934. The size composition likewise changed from small and medium fish in January to relatively more large fish in March, especially in catches made in the southern part of the ground.

Thus it appears that because of the erratic changes in size composition even within short parts of a single season occurring simultaneously with marked changes in hydrographic conditions, that the fluctuations in the catch per day's fishing reflect changes in availability caused by movements of fish more than changes in abundance.

Summary of Winter Fishery

1. The offshore fishery for scup, sea bass, and fluke has developed rapidly since the winter of 1929, both in the number of vessels and in total catch. The catch of scup increased from approximately 1.7 million pounds in the winter of 1931 to 3.8 million pounds in 1935.

2. The fluctuations in the catch of scup, as measured by catch per day's fishing, reflect changes in availability more than changes in abundance.

3. Sharp changes in size composition of the scup catches from large fish in one winter to smaller sizes in other winters and vice versa and similar changes within short periods of a single season are apparently correlated with changes in hydrographic conditions.

4. With considerable cooling of the water in the late autumn and winter from Cape Hatteras to Cape May, scup are generally

found near the edge of the Continental Shelf in depths 40 fathoms or more and particularly in the southern part of the ground (easterly of Bodie Island) in depths 25 to 50 fathoms. When relatively less cooling occurs, scup are generally scattered over the central part of the general fishing area (easterly of Chesapeake Lightship) in depths 20 to 40 fathoms. Usually better catches are made in a "cold winter", because the scup are more concentrated and available in a relatively small part of the fishing ground.

5. Discarding at sea of large quantities of small scup in some winters suggests the need for practical gear modification to correct this wasteful practice.

TAGGING STUDIES

Accurate appraisal of the general stock of scup and proper understanding of the importance and causes of fluctuation in catch involve the determination of whether or not separate population units exist, and the extent of the availability of each to the general fishery or to the separate fisheries in certain localities of the general range. The identification of separate units can often be traced by a comparison of age and size composition in the catch, varying fluctuations in yield, and more directly by tagging experiments.

In the preceding discussion of the fluctuations in the catch of the summer and winter fisheries, evidence from the analysis of age and size composition, together with changes in catch, suggests that the summer and winter fisheries draw on the same general stock, since the catch of each has included the same broods of fish, and that fish available to the summer fisheries at various parts of the coast apparently migrate in the autumn to the region of the winter fishery and mix. Direct evidence of this was obtained from the results of tagging.

From 1931 to 1934 inclusive, 7,160 scup were tagged and released in the summer and winter fisheries. In the summer fishery, scup were tagged near the northern and southern ends of the range; namely, Woods Hole, Mass., and Wildwood, N.J. In the winter trawl fishery, scup were tagged at a sufficient number of locations as to be representative of the general region being fished by the majority of the fleet. Several types of tags were used, the best results being obtained with a modified type of Scottish plaice label (external tag) and the "belly tag" (internal tag). Modification of the plaice label and development of the belly tag is credited to Robert A. Nesbit of the Bureau (Nesbit, 1933). The external tags consisted of two lamenated celluloid disks, 25/1000-inch thick and 1/2-inch diameter. These were attached to the middorsal region by a pin of pure nickel wire, .032 inch in diameter. One of the disks was white and numbered; the other was red with printed instructions of return address and notice of reward ($1). The internal tag used in the earlier experiments consisted of a strip of bright red celluloid 25/1000-inch thick, 1-1/4-inch long, 1/4-inch wide, and printed and numbered (fig. 13). In later experiments, tags 1-1/4-inch long and 5/16-inch wide were used--one side bears a number, instructions for return, and notice of reward; and the other side bears a request for additional information on locality and date of capture and length of the fish. The internal tag was inserted in the body cavity through a small incision in the body wall. To date (January 1, 1937), 113 tags have been returned (1.6 percent). Releases and recaptures of tagged scup from these experiments are listed in tables 20, 21, and 22 and charted in figure 14.

From these experiments, it was definitely learned that the scup migrate in the autumn from the summer fishing grounds along the shores of southern New England and New Jersey to the winter fishing grounds off the Virginia Capes and in the spring, make a return migration from the winter grounds to the summer area. Thus, it was demonstrated that the winter fishery draws on all contingents of the stock available to the summer fishery.

Doubt, however, whether the entire summer fishery draws on a common stock was raised

Figure 13.--Types of tags used in the study of scup migrations.

by the results of these tagging experiments, for they suggested the possible existence of two independent population units in the summer fishery from New Jersey to southern New England. For example, the returns of tagging suggested one unit common to southern New Jersey and another to southern New England. Scup marked and released in the autumn of 1931 off southern New Jersey migrated to the region of the winter trawl fishery off the Virginia Capes as indicated by returns in the first winter subsequent to tagging and returned in the following spring to the general area in which they were tagged (fig. 14, table 20). No recaptures were reported north of the central part of the coast of New Jersey (north of Atlantic City). On the other hand, scup tagged and released in several summers at Woods Hole, Mass., were recaptured in the first winter following the tagging period in the southern winter fishery. In the subsequent spring and summers, most of the Woods Hole scup returned to the region of tagging; a few were taken as far westward as the western end of Long Island, N.Y., but of the 24 summer recaptures, only 4 were reported from New Jersey, and these were all from the northern part of the State (fig. 14, tables 20, 21).

It is admitted that the small number of returns (less than 2 percent) from these experiments casts some doubt on the reliability of a conclusion that separate units exist near the southern and northern ends of the range of the species. Similar results were secured from each of five experiments carried out in each of 4 years so that the segregation cannot be looked upon as reflecting exceptional behavior in a single year.

The suggestion that the New York-southern New England fishery draws on a population unit separate from the New Jersey fishery as indicated by tag returns is not clearly evident from the analysis of biological and catch record data. It has been demonstrated that the same year classes that have been present in the New Jersey fishery have appeared subsequently in the pound net and trap fisheries at Fire Island, N.Y., and Newport, R.I. (fig. 6) and that at the latter places the catch has increased simultaneously with the appearance of these fish. If this is the result of an incursion of the same fish that were present along the New Jersey coast in the preceding year or two, it is in opposition to the results of the tagging experiments, for the latter would suggest that the New Jersey and the New York-Rhode Island fisheries draw on different population units rather than the

Table 20.--Summary of recaptures of scup tagged and released in the summer and winter fisheries, 1931-33[1]

Released		Recaptured							
Locality and date	Fish tagged	Current winter		Current summer		First subsequent winter[2]		First subsequent summer	
	Number	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]
Summer fishery:									
Wildwood, N. J.									
September-October 1931..	1,503	-	-	2	.13	3	.20	8	.54
Woods Hole, Mass.									
June-July 1931.....	996	-	-	13	1.30	1	.10	2	.20
June 1932.....	[4] [5] 982	-	-	19	1.93	1	.10	5	.51
October-November 1932...	[4] [5] 447	-	-	2	.45	2	.45	4	.90
November 1933.....	[5] 341	-	-	-	-	1	.29	9	2.64
November 1933.....	[5] 442	-	-	-	-	1	.23	-	-
October 1934	489	-	-	-	-	2	.41	9	1.84
November 1934	71	-	-	-	-	-	-	-	-
Winter fishery:[2]									
Off Virginia Capes									
January-March 1932.....	1,301	6	.46	-	-	-	-	9	.69
January-March 1933.....	588	1	.17	-	-	-	-	1	.34

Released		Recaptured							
Locality and date	Fish tagged	Second subsequent summer		Third subsequent summer		Fourth subsequent summer		Total	
	Number	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]
Summer fishery:									
Wildwood, N. J.									
September-October 1931..	1,503	-	-	-	-	-	-	13	.87
Woods Hole, Mass.									
June-July 1931.....	996	1	.10	-	-	-	-	17	1.70
June 1932.....	[4] [5] 982	1	.10	1	.10	-	-	27	2.74
October-November 1932...	[4] [5] 447	4	.90	1	.22	2	.44	15	3.36
November 1933.....	[5] 341	-	-	2	.58	-	-	12	3.51
November 1933.....	[5] 442	-	-	-	-	-	-	1	.23
October 1934.....	489	-	-	-	-	-	-	11	2.25
November 1934.....	71	-	-	-	-	-	-	-	-
Winter fishery:[2]									
Off Virginia Capes									
January-March 1932.....	1,301	-	-	-	-	-	-	15	1.15
January-March 1933.....	588	-	-	-	-	-	-	2	.51

[1] Data from tables 21 and 22.
[2] Otter trawl fishery off Virginia Capes.
[3] Percent - $\frac{\text{recaptured} \times 100}{\text{released}}$
[4] Fish doubly tagged, but considered as "one return" when the two tags (external and internal) were recovered from same fish.
[5] After tagging, fish held 7 to 10 days before being released.

same population units, but at different times in their period of life.

On the other hand, it might be argued that the same conditions that caused the great abundance of several successive year classes along the New Jersey coast after 1927 were equally effective in producing large numbers of scup of the same year classes in a unit common to Rhode Island and New York, but for unknown reasons, perhaps environmental, the main body of those small fish are not readily available to the inshore gear at the more northern points of the range. The facts--the main season for scup at New York and Rhode Island is short (about 2 months) and their small sizes appear at the end of that short season--suggest that the scup may be available only for a short time in the inshore trap area and that not till later, as older and larger fish, do they change their habits and movements so as to become more available not only by appearaing at the beginning of the season but also by trapping more readily when moving in large spawning schools close inshore.

Table 21.--Recaptures of scup tagged and released at Woods Hole, Mass., and at Wildwood, N. J., summers of 1931 to 1934

[P.N. = pound net; F.T. = floating trap; O.T. = otter trawl; H.L. = handline.]

Released and recaptured	Caught by	Tags returned[1]				Length when released
		External		Internal		
		Tag number	Date	Tag number	Date	
						Cm.
Experiment I						
Released:						
996 scup, June 20 to July 6, 1931, Woods Hole, Mass., marked with external tags	P.N.					
Recaptured:						
Locally, 1931:						
Off Woods Hole, in Buzzards Bay	P.N.	85162	July 2	-	-	23.0
-do-	P.N.	85453	July 6	-	-	29.0
-do-	P.N.	85587	July 7	-	-	22.0
Off Nonamesset Island, in Vineyard Sound	H.L.	86202	July 18	-	-	26.5
Off Nobska Point, in Vineyard Sound	H.L.	85434	Aug. 9	-	-	24.0
Off Tarpaulin Cove, in Vineyard Sound	H.L.	85696	Aug. 11	-	-	26.5
Off Naushon Point Shoal, in Buzzards Bay	H.L.	86061	Aug. 15	-	-	27.0
Off Woods Hole, in Buzzards Bay	P.N.	85638	Aug. 20	-	-	23.5
Off Tarpaulin Cove, in Vineyard Sound	H.L.	85689	Aug. 26	-	-	28.5
Muskeget Channel, Nantucket Sound	O.T.	86209	Aug. 28	-	-	29.0
Muskeget Channel, Nantucket Sound	O.T.	85964	Aug. 28	-	-	31.0
Off Kettle Cove, in Buzzards Bay	P.N.	85620	Oct. 1	-	-	19.5
Off Naushon Point Shoal, in Buzzards Bay	H.L.	85810	Nov. 3	-	-	20.5
Southern trawl fishery, winter 1932:						
40 miles E. of Hog Island, Va.	O.T.	85308	Jan. 6	-	-	19.5
Summer fishery, 1932:						
Off Newport, R. I.	F.T.	85632	June 3	-	-	29.5
Muskeget Channel, Nantucket Sound	O.T.	86046	June 26	-	-	26.0
Summer fishery, 1933:						
Locality not determined						
Reported through market, Brooklyn, N. Y.	-	85331	July 8	-	-	21.5
Experiment II						
Released:						
1,503 scup. Sept. 16 to Oct. 3, 1931 off Wildwood, N. J., marked with external tags	O.T.					
Recaptured:						
Locally, 1931:						
1 mile ESE. McCries Shoal Buoy	O.T.	86304	Oct. 3	-	-	21.0
2½ miles SE. ½ S. McCries Shoal Buoy	O.T.	86380	Oct. 3	-	-	24.5
Southern trawl fishery, winter 1932:						
48 miles E. x N. Hog Island, Va.	O.T.	86398	Feb. 6	-	-	24.5
35 miles E. x S. Chesapeake Lightship	O.T.	82210	Mar. 23	-	-	24.0
Locality not determined						
Reported through market, Yorktown, Va.	O.T.	86638	Feb. 9	-	-	23.5
Summer fishery, 1932:						
Black Fish Bank off Chincoteague Inlet, Va.	O.T.	86522	May 30	-	-	24.0
5 miles E. Overfalls Lightship	H.L.	86526	July 3	-	-	25.0
2 miles SE. McCries Shoal Buoy	O.T.	82299	Sept. 27	-	-	23.5
5½ miles NW. x W. Five Fathom Bank Lightship	O.T.	82284	Oct. 14	-	-	23.5
Locality not determined						
Reported through market, Wilmington, Del.	-	82739	Apr. 6	-	-	24.0
Reported caught off Cape May, N. J.	-	82376	Apr. 24	-	-	24.5
Reported caught off New Jersey coast	-	82895	May 29	-	-	21.5
Reported through market, Westchester, Pa.	-	82913	Aug. 1	-	-	25.0
Experiment III						
Released:						
982 scup, June 4 to 8, 1932, Woods Hole, Mass., each fish marked with an external and an internal tag	P.N.					

Table 21.--Recaptures of scup tagged and released at Woods Hole, Mass., and at Wildwood, N. J., summers of 1931 to 1934--Continued

[P.N. = pound net; F.T. = floating trap; O.T. = otter trawl; H.L. = handline.]

Released and recaptured	Caught by	Tags returned[1]				Length when released
		External		Internal		
		Tag number	Date	Tag number	Date	
						Cm.
Experiment III--Continued						
Recaptured:						
Locally, 1932:						
Off Woods Hole, in Buzzards Bay	P.N.	2449	June 9	93749	June 9	18.5
-do-	P.N.	2720	June 9	94020	June 9	20.0
-do-	P.N.	2863	June 9	94163	June 9	18.5
-do-	P.N.	2973	June 9	94273	June 9	18.5
-do-	P.N.	3189	June 10	94490	June 10	25.0
Cross Rip, Nantucket Sound	O.T.	2805	June 20	-	-	22.0
Off Woods Hole, in Buzzards Bay	P.N.	3045	June 21	-	-	20.0
Off Nonamesset Island, in Vineyard Sound	H.L.	3090	Aug. 7	-	-	23.5
Off West Chop, in Vineyard Sound	H.L.	3051	Aug. 17	-	-	28.5
Onset Bay, Mass.	H.L.	2847	Aug. 18	-	-	19.5
1 mile NW. Wing's Neck Lightship, in Buzzards Bay	H.L.	3255	Aug. 21	-	-	20.0
Off Wareham, in Buzzards Bay	H.L.	2579	Sept. 2	-	-	19.0
Off Wings Neck, in Buzzards Bay	H.L.	2524	Sept. 9	-	-	19.5
On beach, Poponesset, Mass.	-	3285	Nov. 16	-	-	20.0
Distant, 1932:						
Off Narragansett Pier, R. I.	F.T.	2644	June 29	-	-	21.0
5 miles S. Watch Hill, R. I.	F.T.	3001	Sept. 15	-	-	19.5
On beach, Sokonnet, R. I.	-	-	-	93900	Sept. 6	18.5
Locality not determined, 1932						
Reported by individual, Watertown, Mass.	-	2499	Aug. 23	-	-	20.0
Reported through market, New York, N. Y.	-	3004	Oct. 7	94304	Oct. 7	-
Southern trawl fishery, winter 1933:						
Locality not determined						
Reported through market, Brooklyn, N. Y.	O.T.	-	-	94434	Mar. -	21.0
Summer fishery, 1933:						
Sheepshead Bay, N. Y.	H.L.	-	-	94367	June 17	24.5
-do-	H.L.	3103	Aug. 16	94403	Aug. 16	23.5
Locality not determined						
Reported through market, Brooklyn, N. Y.	-	-	-	94373	July 19	22.5
-do-	-	-	-	94382	July 20	24.0
-do-	-	-	-	94414	Sept. 15	20.5
Southern trawl fishery, winter 1934:						
Locality not determined						
Reported through market, Philadelphia, Pa.	O.T.	-	-	94068	Jan. 29	20.0
Summer fishery, 1935:						
Jamaica Bay, N. Y.	H.L.	-	-	94584	Aug. 17	18.5
Experiment IV						
Released:						
447 scup, Oct. 11 to Nov. 5, 1932, Woods Hole, Mass., each fish marked with an external and internal tag	P.N.					
Recaptured:						
Locally, 1932:						
Off Kettle Cove, in Buzzards Bay	P.N.	3569	Oct. 17	-	-	21.0
Off Cross Rip Lightship, in Nantucket Sound	O.T.	3435	Oct. 24	97133	Oct. 24	23.5
Southern trawl fishery, winter 1933:						
30 miles E. Chesapeake Lightship	O.T.	3565	Jan. 5	-	-	22.0
60 miles SE. x E. Cape Henry	O.T.	3779	Mar. 29	-	-	24.0
Summer fishery, 1933:						
Sag Harbor, Long Island, N. Y.	H.L.	3415	July 9	-	-	20.0
Off Wings Neck, in Buzzards Bay, Mass.	H.L.	-	-	97382	Aug. 5	22.5

Table 21.--Recaptures of scup tagged and released at Woods Hole, Mass., and at Wildwood, N. J., summers of 1931 to 1934--Continued

[P.N. = pound net; F.T. = floating trap; O.T. = otter trawl; H.L. = handline.]

Released and recaptured	Caught by	Tags returned[1]				Length when released
		External		Internal		
		Tag number	Date	Tag number	Date	
Experiment IV--Continued						
Recaptured--Continued						Cm.
Summer fishery, 1933--Continued						
Locality not determined						
Reported through market, New York, N. Y.	-	-	-	97010	Aug. 17	21.5
Reported through market, Bethlehem, Pa.	-	-	-	97126	June 30	23.5
Summer fishery, 1934:						
Harbor, Boston, Mass.	H.L.	-	-	97091	June 5	19.5
Off Newport, R. I.	F.T.	-	-	97522	June 10	22.5
Off Beach Haven, N. J.	P.N.	-	-	97207	June 16	23.5
Locality not determined						
Reported through market, New York, N. Y.	-	-	-	97112	Apr. 28	20.0
Summer fishery, 1935:						
Locality not determined						
Reported through market, Baltimore, Md.	-	-	-	97080	Sept. 2	18.5
Summer fishery, 1936:						
Off Newport, R. I.	F.T.	-	-	97163	June 12	22.5
Locality not determined						
Reported through market, Patterson, N. J.	-	-	-	97033	Oct. 8	19.5
Experiment V						
Released:						
341 scup, Nov. 9, 1933, Woods Hole, Mass., marked with an internal tag	P.N.					
Recaptured:						
Southern trawl fishery, winter 1934:						
Locality not determined						
Reported through market, New York, N. Y.	-	-	-	113122	Feb. 2	18.5
Summer fishery, 1934:						
Off southern New Jersey	-	-	-	113223	Apr. 16	20.0
Off Newport, R. I.	F.T.	-	-	113512	May 24	19.0
Off Rockaway Point, Long Island, N. Y.	H.L.	-	-	113362	June 7	20.0
2 miles off Swifts Beach, Wareham, Mass.	H.L.	-	-	113331	July 14	18.0
Off Coney Island, N. Y.	H.L.	-	-	113116	July 23	19.0
Off Mattapoisett, Mass.	H.L.	-	-	113434	Aug. 26	19.5
Locality not determined						
Reported through market, Brooklyn, N. Y.	-	-	-	113243	Apr. 16	28.0
Reported through market, Philadelphia, Pa.	-	-	-	113260	Apr. 20	19.5
Reported through market, Providence, R. I.	-	-	-	113563	Sept. 12	18.5
Summer fishery, 1936:						
Locality not determined						
Reported through market, Pawtucket, R. I.	-	-	-	113582	May 20	19.5
Reported through market, Staten Island, N. Y.	-	-	-	113489	Nov. 9	19.5
Experiment VI						
Released:						
442 scup, Nov. 9, 1933, Woods Hole, Mass., marked with an external tag on occipital crest	P.N.					
Recaptured:						
Southern trawl fishery, winter 1934:						
50 miles E. x S. ½ S. Chesapeake lightship	O.T.	7268	Mar. 12	-	-	19.0

Table 21.--Recaptures of scup tagged and released at Woods Hole, Mass., and at Wildwood, N. J., summers of 1931 to 1934--Continued

[P.N. = pound net; F.T. = floating trap; O.T. = otter trawl; H.L. = handline.]

Released and recaptured	Caught by	Tags returned[1]				Length when released
		External		Internal		
		Tag number	Date	Tag number	Date	
Experiment VII						
Released:						Cm.
489 scup, Oct. 27 to 28, 1934, Woods Hole, Mass., each fish marked with an external and internal tag (U-shaped)	P.N.					
Recaptured:						
Southern trawl fishery, winter 1935:						
Locality not determined						
Reported through market, Brooklyn, N. Y.	-	8016	Mar. 27	-	-	22.5
Reported through market, Newark, N. J.	-	8195	Apr. 10	-	-	22.5
Summer fishery, 1935:						
Off Rockaway Beach, N. Y.	H.L.	8251	June 12	-	-	21.5
Off Seal Rock, Newport, R. I.	F.T.	8191	June 16	-	-	22.5
Off Orient Point, in Long Island Sound, N. Y.	P.N.	8162	July 2	-	-	20.5
Marion Harbor, in Buzzards Bay, Mass.	H.L.	-	-	114689	July 3	18.5
Off Long Branch, N. J.	H.L.	-	-	114574	Sept. 8	20.0
Off Elberon, N. J.	H.L.	-	-	114559	Sept. 15	19.5
Off Seabright, N. J.	H.L.	-	-	114286	Sept. 26	19.5
Off So. Dartmouth, in Buzzards Bay, Mass.	H.L.	-	-	114324	Oct. 8	20.0
Locality not determined						
Reported through market, New York, N. Y.	-	-	-	114338	Aug. 29	21.0
Experiment VIII						
Released:						
71 scup, Nov. 14, 1934, Woods Hole, Mass., marked with internal tags (U-shaped)	P.N.					
Recaptured:						
None to January 1, 1937	-	-	-	-	-	-

[1] To January 1, 1937.

A third possible explanation may be that the rise in catch at New York and Rhode Island might have been due to a combination of an influx of "New Jersey fish" simultaneously with the presence in average abundance of the same year classes of a unit local to New York-Rhode Island. This "overflow" from New Jersey might not have extended to or been of relative importance as far eastward as Woods Hole where all fish of the northern tagging experiments were originally caught, marked, and released. Thus, it is probable that fish tagged at this point were primarily of a "local unit" and although returns indicated a spread of the unit westward to Rhode Island, New York, and New Jersey, distinctness and presence of this "Woods Hole" unit at the latter places may have been masked in recent years by an "overflow" of fish from New Jersey where the species have been unusually abundant since 1929.

Of these three possibilities, it appears that the third, the incursion into the northern area along New York and Rhode Island of large numbers of scup of broods that had been present as smaller-sized fish along the New Jersey coast in preceding summers, together with local fish of the same year classes, caused the rise in catch in 1931 in the New York-Rhode Island pound net and trap fishery and the upward trend to 1935.

As to the relationships of populations in different areas, the conclusion is that all parts of the summer fishery, together with the winter fishery, draw on a common stock of scup.

Table 22.--Recaptures of scup tagged and released in the southern otter-trawl fishery off the Virginia Capes, winters of 1932 and 1933

[O.T. = otter trawl; P.N. = pound net; H.L. = handline]

Released and recaptured	Caught by	Tags returned[1]		Length when released
		Tag number	Date	
1932				
Released:				*Cm.*
1,301 scup, January to March, inclusive, in general area from lat. 35° 10' N. to lat. 38° 10' N., 20 to 60 fathoms, marked with external tags	O.T.			
Recaptured:				
Southern trawl fishery:				
Locally, winter:				
36 miles S. x E. Winterquarter Lightship	O.T.	486	Mar. 19	20.0
65 miles E. Cape Henry, Va.	O.T.	866	Mar. 25	26.5
20 miles SE. Winterquarter Lightship	O.T.	1821	Apr. 5	25.5
Locality not determined:				
Reported through market, Portsmouth, Va.	O.T.	150	Jan. 18	25.5
Reported through market, New York, N. Y.	O.T.	837	Feb. 20	22.0
Reported through market, Old Point Comfort, Va.	O.T.	1572	Apr. 11	24.5
Summer fishery:				
8 miles SE. Assateague Lightship	O.T.	425	May 7	23.0
Off Winterquarter Shoals	O.T.	1502	May 27	27.5
Off Cape May, N. J.	O.T.	840	May 29	26.5
Off North Long Branch, N. J.	P.N.	779	June 28	23.5
Off Wildwood, N. J.	O.T.	1624	July 5	24.5
6 miles S. Barnegat Lightship	P.N.	984	July 19	23.5
Off Cape May, N. J.	H.L.	752	Aug. 8	23.0
1 mile NW. Cape May Point Lightship	H.L.	991	Aug. 24	23.5
4 miles E. Chincoteague Inlet	H.L.	1629	Sept. 5	28.0
1933				
Released:				
588 scup, January to March, inclusive, in general area from lat. 36° 40' N. to lat. 38° 10' N., 40 to 60 fathoms, marked with external tags	O.T.			
Recaptured:				
Southern trawl fishery:				
Locally, winter:				
65 miles SE. Cape Henry, Va.	O.T.	4216	Apr. 10	20.5
Summer fishery:				
Off Beach Haven, N. J.	H.L.	4248	June 17	19.0

[1] To January 1, 1937.

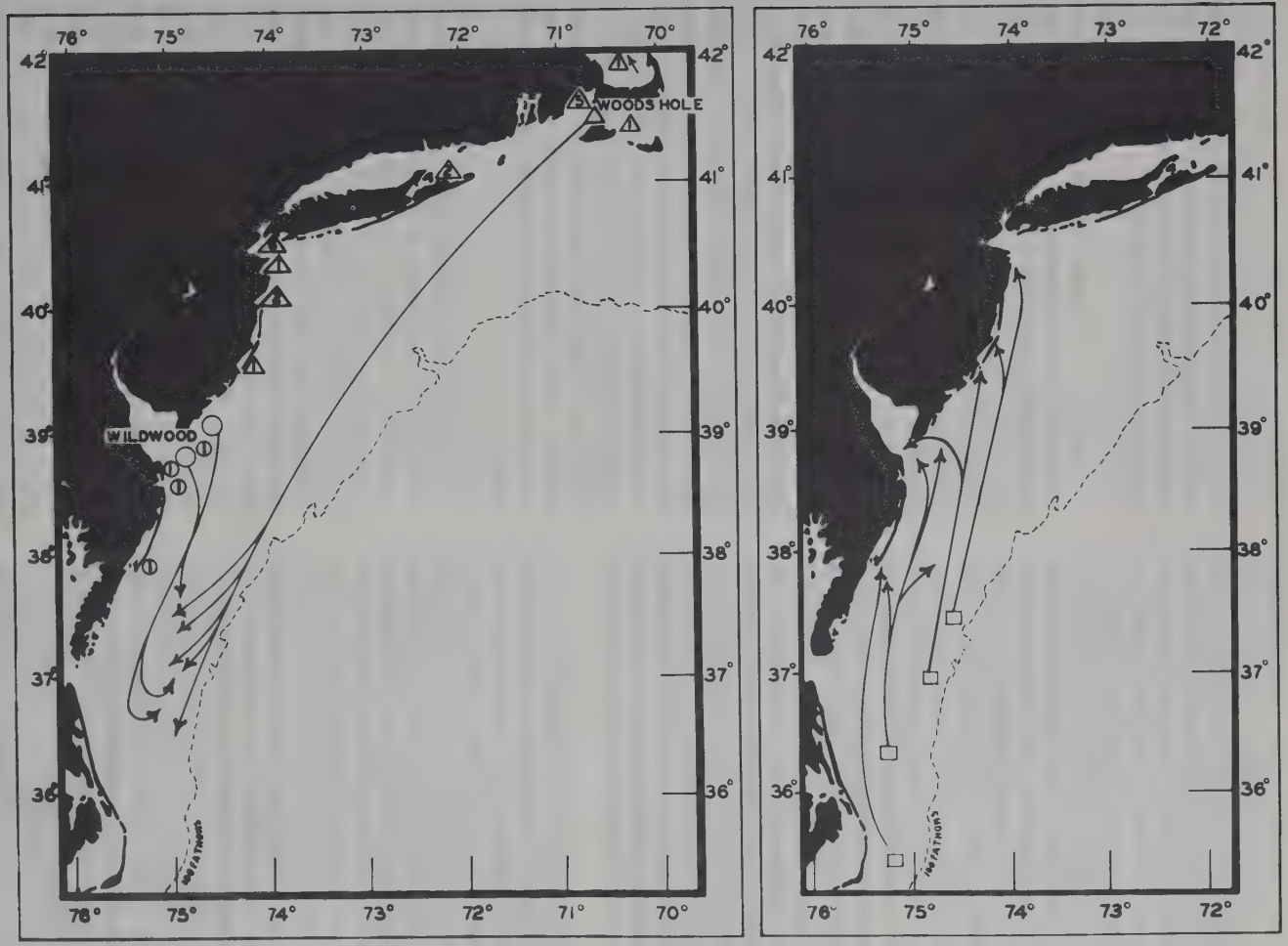


Figure 14.--Localities of recaptures of tagged scup.

DISCUSSION

The extent of the landings by the combined effort of the summer and winter fisheries has been the cause of concern and has raised the question as to whether or not the stock can withstand indefinitely the present amount of exploitation. Increased fishing effort during the past several years has been due largely to increased development and activity of the summer seine and trawl fisheries and more recently (1930) to the rapid expansion of the winter trawl fishery.

The major fluctuations in yield prior to 1929 were mainly the result of natural changes in abundance, but since that year, changes in yield have been further affected by increased fishing effort. Despite this increase in exploitation, there has been no decline in abundance. That the stock is not exposed to excessive fishing is indicated by continued high yields of the summer and winter fisheries and by the relatively small number of returns from summer and winter tagging experiments.

It does not necessarily follow that the scup fishery is entirely free from conditions and practices that may result in the future diminution of the stock to the point where commercial fishing for the species becomes temporarily unprofitable. It has been pointed out that the present year-round fishing may be expected to continue and increase in activity. The stock may be subject to fluctuations in numbers as the result of changes in availability and in variation of annual increments to the stock as the result of changes in the relative success or failure of reproduction. This may, as in the past, cause a decline in abundance so as to materially reduce the population of scup. When this happens, the decline of commercial-sized fish will be much sharper than in the past because of the greatly increased fishing effort.

To render such inevitable decline less severe and to maintain best possible catches, the available supply should be wisely utilized. The present destruction of undersized and small unmarketable scup by both the summer and winter fisheries is contrary to this end and constitutes an unnecessary obstacle to the continuance of the present high-catching rate. This practice, however, is not unpardonable as many would assume, nor is its continuance reasonably justified.

Argument in support of its continuance can be based on the ground that as long as scup are abundant and in excess of market demands so much as to constitute a glut, no harm is done in destroying young fish. In fact, it may be argued that if the species is enormously abundant, "thinning out" of the stock by destruction of the smaller sizes would improve conditions for the older and larger market fish, because less crowding would allow better development of market sizes and tend to diminish the rate of natural mortality, all of which would tend to compensate for the destruction of the smaller and less marketable sizes. This, it might be argued, would be comparable in results to the practice of transplanting fish from crowded areas to regions of more ample food supply and less crowding. This is the practice of many years in the plaice fisheries of certain European countries bordering the North Sea (Blegvad, 1935).

However, the opinion that destruction of small fish constitutes a needless waste and obstacle to continued good yields is worthy of careful consideration, especially in light of results of the present study. Since the scup population is subject to very sharp, natural changes in abundance, it is apparent that the stock can reach exceedingly low levels irrespective of the amount of fishing effort prevailing. This has been convincingly demonstrated at various times during the history of the fishery. Hence, in the periods of low abundance, the small fish of marketable size would be extremely valuable, and those below legal limit would be a source of revenue if allowed to grow another year or two. In addition, the survivors among these young and small fish would have to carry the burden of the whole fishery for scup, both in winter and summer, until the next good year class or classes came along. Fishing activity by that time might be so increased that a diminished supply of small fish would be quickly caught

up even before they attained marketable size, leaving practically no survivors for future catching so that the yield would be mainly fish of a size now classified as "small". This is essentially what has happened in the haddock fisheries of the North Sea (Herrington, 1935).

It might also be argued that in the winter fishery sea bass and fluke, which comprise an important part of the catch because of their high market value and as such are subject to concentrated fishing effort, may not continue at their present level of abundance. In fact, it is the opinion of some captains engaged in this fishery that these species cannot be depended upon to furnish good catches indefinitely unless something is done to lessen the strain on them. If the fishery for sea bass and fluke becomes less remunerative, the whole effort of the winter fishery would then be directed mainly to scup and perhaps to a lesser extent to croakers. The amount of destruction of small fish, if the present practice is continued, would be greatly increased, and the available supply of the larger market sizes more rapidly diminished. This would affect not only the winter trawl fishery, but also reduce the summer catch of scup, since both the winter and summer fisheries draw on the same stock.

It appears that much could be gained by eliminating or at least greatly reducing the destruction of small sizes, the principal benefits to the industry being: (1) Increased value within 1 or 2 years of the survivors of the small fish as they grow in size and become higher grade market fish; (2) steadier prices for the more desirable, salable sizes by elimination or reduction of market gluts, particularly when small fish are especially numerous; and (3) prolongation of good catches when natural decline in abundance occurs.

The important question then is, "How can this be accomplished?" Admittedly it is difficult, for the method of correction must be practical; that is, it must not impose inconvenience or expense in excess of the probable gain. In European and certain American fisheries, it has been demonstrated that practical modifications in gear to release undersized fish are quite feasible, but their acceptance into everyday use by the fishermen is most difficult to obtain (Russell, 1934; Herrington, 1935).

In the scup fishery, as already stated, the destruction of small fish takes place both in the summer and winter fisheries. In individual cases, especially in the summer trap fishery at Newport, R.I., conscientious effort is made to release most of the undersized fish in good condition by allowing them to escape when the trap is hauled, either by means of a large mesh "sifter" or by merely running them over the cork lines. In general, however, this method of correction is not generally applicable to places where the catch is composed of a mixture of different kinds of fish, for the use of a "large mesh sifter" at such places might result in loss of marketable fish other than scup, either by escapement through the "apron" or by gilling. At Newport this device is used to sift catches composed almost entirely of scup and little else.

In the winter trawl fishery, although many captains are cognizant of the probable effect of continued destruction of small fish on future yield, the present conditions of fishing make it practically impossible for them to accomplish any real savings of unsalable sizes without certain changes in gear. In the otter trawl fishery, the catch is dependent on results of towing on or near the bottom usually for periods of 1 to 2 hours, depending on conditions. Consequently, the composition of the catch (kind and size of fish) is not definitely known until the haul is landed on deck. Such small fish as may be in the net are by then usually in poor condition from confinement and crowding during the towing and hauling of the net, and even if they were returned immediately to the sea, few are likely to survive. In actual practice, the trash, including both undersized and unmarketable sizes, is not cleared from the deck until all of the market fish have been culled from the haul; consequently, the trash fish are usually dead or nearly so by the time they are thrown overboard. Hence, the remedy must lie in the elimination of the undesirable sizes from the catch by escapement in good condition while

the net is being towed. European and American experiments have demonstrated convincingly that this can be accomplished by increasing the size of mesh, particularly in the cod end (Davis, 1934; Herrington, 1935).

It is acknowledged that the adoption of such a modification in gear by the winter trawl fishery involves careful consideration of all conditions under which the fishery operates. Foremost among these is the fact that the catch of this southern fishery consists of several different species differing markedly from each other in shape and length. In addition to scup, the catch is composed of sea bass, fluke, croakers, and lesser quantities of butterfish *(Poronotus tricanthus)* and squeteague *(Cynoscion regalis)*. It is the opinion of many of the fishing captains engaged in the winter trawl fishery that a change to a larger size of mesh in the cod end in excess of that now in use would cause the loss of marketable sizes of fish other than scup. For example, it is their belief that increase in size of mesh of the cod end above present dimensions (2-1/2 to 3 inches stretched measurement) would result in the loss of the small but marketable-sized butterfish and squeteague by escapement through the mesh and the loss of good "market croakers" by gilling. Hence, the importance of "saving" the small and undersized scup relative to the catch as a whole is a debatable question.

On the other hand, in some winters, depending on conditions, scup constitute a major portion of the catch. In addition, especially in recent years, it has comprised an important part of the catch of the summer inshore fishery, particularly along the New Jersey coast, and in some regions, as in Rhode Island, for years has accounted for practically the total catch of the principal fisheries of the region. Because of the importance of scup in the summer and winter fisheries, it is advisable to determine whether the prevailing destruction of the young and small sizes can be effectively reduced and whether this can be done without excessive loss of other market species.

SUMMARY

1. The scup population of the Atlantic coast constitutes an important part of the catch of a fishing industry of major commercial and recreational importance.

2. The total catch over the past 50 years has fluctuated widely and abruptly within relatively short periods of time.

3. The catch per unit of effort has also fluctuated widely, because of changes in availability which, in the summer fishery, resulted principally from changes in abundance and, in the winter fishery, from changes in movements of the fish.

4. Fluctuations in the catch of the summer fishery were due mainly to differences in the size of the increments added to the population by succeeding year classes, which apparently has been caused by variations in the relative success of reproduction of annual broods.

5. Fluctuations in the catch of the winter fishery were due mainly to differences in the amount of cooling of the water over the general fishing area in the several winters, scup being more available in a cold winter by being more concentrated in a relatively small and easily accessible part of the ground.

6. Although the fluctuations in catch of the summer and winter fishery have resulted from different causes, results of tagging and observations of size composition reveal that both fisheries draw on the same general stock.

7. The stock of scup is now (1935) at a high level of abundance despite the much increased fishing activity of the past 5 years, the increase resulting mainly from the development of the winter fishery and from the increased activity of the summer otter trawl fishery.

8. The recovery to a record high level of abundance in 1929 following a period of unusually low yields (1926–28) took place when the number of adult fish were not especially numerous and suggests that success of reproduction of large broods is not wholly dependent on the presence of a large spawning reserve of old fish.

9. A natural decline in abundance can reasonably be expected on the basis of past history of the fishery and, when it occurs, will be greatly accelerated as compared with decline in the past because of the greatly increased fishing activity.

10. Corrective measures effecting a reduction in the prevailing destruction of undersized and small, but legally marketable, scup would retard the expected decline in abundance and would tend to minimize fluctuations in the commercial catch of the species.

ACKNOWLEDGMENTS

As in any study of this nature, the attainment of results has been possible only through the cooperation, advice, and material assistance of many persons. Numerous members of the Bureau of Fisheries staff have assisted the authors greatly with advice on planning the study, collection and analysis of data, and the preparation of this report. Henry B. Bigelow of Harvard University provided helpful criticisms, particularly of that phase dealing with the hydrography of the region in which scup occurs; the Woods Hole Oceanographic Institution made available the research vessel *Atlantis* from which many hydrographic data were collected; and Frederic McMurray, officers, and crew of the *Atlantis* gave us their assistance. Members of the fishing industry, dealers, pound net and trap operators, and captains and crews of fishing vessels gave excellent cooperation in field work. They made available their establishments, vessels, and equipment in the collection of data, and provided invaluable information on record of catch, habits of fish, practices of the industry, and much other information without which this report would not have been possible.

LITERATURE CITED

BAIRD, SPENCER F.
1873. Report on the condition of the sea fisheries of the south coast of New England in 1871 and 1872. U.S. Commission of Fish and Fisheries, Part 1, Report of the Commissioner, 852 p.

BIGELOW, HENRY B.
1933. Studies of the waters on the Continental Shelf, Cape Cod to Chesapeake Bay. I. The cycle of temperature. Papers in Physical Oceanography and Meteorology, vol. 2, no. 4, 135 p.

BIGELOW, HENRY B., and WILLIAM W. WELSH.
1925. Fishes of the Gulf of Maine. U.S. Bureau of Fisheries, Bulletin, vol. 40 (1924), part 1, p. 259–261, 263–268, 491–494.

BLEGVAD, H.
1935. Transplantations of plaice from the North Sea to the Belt Sea, 1928–1933. Report of the Danish Biological Station to the Ministry of Shipping and Fisheries, no. 39 (1934), p. 9–84. Copenhagen.

DAVIS, F. M.
1934. A mesh experiment indicating that small fish escape while the trawl is being towed. Conseil Permanent International pour l'Exploration de la mer, Rapports et Procès-Verbaux des Réunions, vol. 39, July, Appendix C, p. 22–26.

HERRINGTON, WILLIAM C.
1935. Modifications in gear to curtail the destruction of undersized fish in otter trawling. [U.S.] Bureau of Fisheries,

Investigational Report No. 24, vol. 1, 48 p.

HOLBROOK, JOHN EDWARDS.
1855. Ichthyology of South Carolina. Vol. I, 2d edition, 1860, p. 175, pl. XXV. Charleston.

LYMAN, THEODORE.
1872. On the possible exhaustion of sea fisheries. Commission on Inland Fisheries of Massachusetts, Sixth Annual Report, p. 17-40. Boston.

NESBIT, ROBERT A.
1933. A new method of marking fish by means of internal tags. Transactions of the American Fisheries Society, vol. 63, p. 306-307.

NESBIT, ROBERT A., and WILLIAM C. NEVILLE.
1935. Conditions affecting the southern winter trawl fishery. [U.S.] Bureau of Fisheries, Circular No. 18, 12 p.

NEW JERSEY (STATE) BOARD OF FISH AND GAME COMMISSIONERS.
1936. Fish and Game Laws.

1922-36. Annual reports. 1921-35.

NEW YORK (STATE) CONSERVATION DEPARTMENT.
1936. The conservation law in relation to fish and game.

PARR, A. E.
1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic coast of the United States. Bingham Oceanographic Collection, Bulletin, vol. 4, art. 3, 90 p.

PEARSON, JOHN C.
1932. Winter trawl fishery off the Virginia and North Carolina coasts. [U.S.] Bureau of Fisheries, Investigational Report No. 10, vol. 1, 31 p.

RUSSELL, E. S.
1934. Size limits and mesh regulations for sea fish. Conseil Permanent International pour l'Exploration de la mer, Rapports et Procès-Verbaux des Réunions, vol. 39, July, p. 1-5.

SOUTHWICK, J. M. K., HENRY T. ROOT, and WILLIAM P. MORTON.
1893. The fluctuations in the number of fish, and the natural causes of their depletion. Annual Report of the Commissioners of Inland Fisheries, January session, 1893. State of Rhode Island and Providence Plantations. p. 9-16.

STEINDACHNER, FRANZ, and LOUIS AGASSIZ.
1872. Fishes taken in Waquoit Weir (Massachusetts) April 18 to June 18, 1871. Commission on Inland Fisheries of Massachusetts, Sixth Annual Report, p. 41-42. Boston.

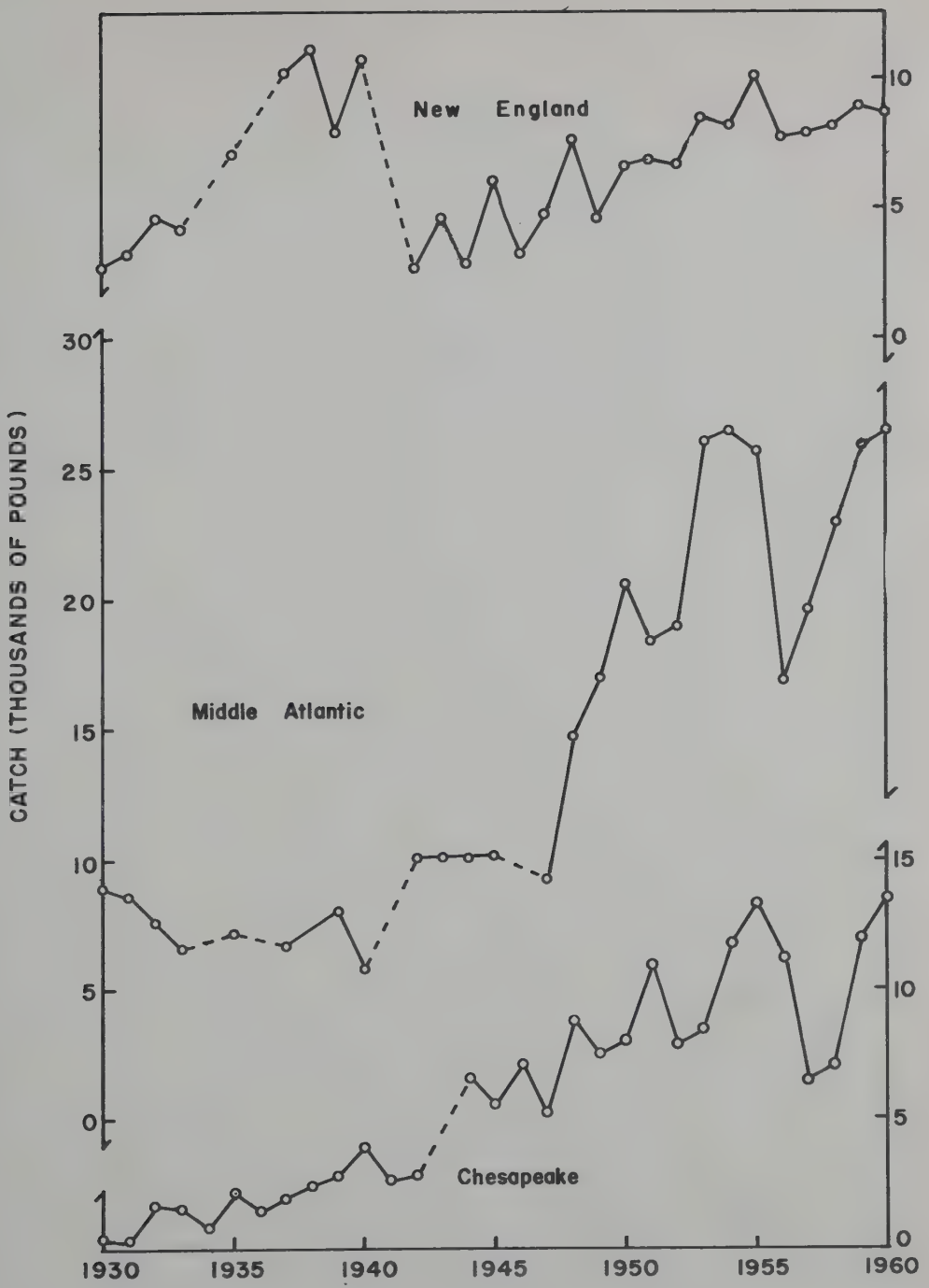
TRUE, FREDERICK W.
1887. The pound-net fisheries of the Atlantic States. In George Brown Goode, The fisheries and fishery industries of the United States. Section V, History and methods of the fisheries, vol. 1, p. 595-610.

U.S. BUREAU OF THE CENSUS.
1911. Fisheries of the United States, 1908. Ch. VII.

U.S. BUREAU OF FISHERIES.
1907. Statistics of the fisheries of the Middle Atlantic States for 1904. Report of the Commissioner of Fisheries for the fiscal year 1905. [U.S.] Bureau of Fisheries Document No. 609, 122 p.

U.S. COMMISSION OF FISH AND FISHERIES.
1884-1905. Reports of the Commissioner, 1882 to 1905.

VIRGINIA.
1936. Laws of Virginia relative to fisheries of tidal waters. The Commissioner of Fisheries of Virginia.



Catch of scup in New England, Middle Atlantic, and Chesapeake Bay States. (Source: U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Statistical Digest 53.)

MS #974

GPO 860-463

Created in 1849, the Department of the Interior--a department of conservation--is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D.C. 20240

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR